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UNION OF SOUTH AFRICA

DEPARTMENT OF COMMERCE AND INDUSTRIES

DIVISION OF FISHERIES
INVESTIGATIONAL REPORT No. 22

THE SOUTH AFRICAN PILCHARD
(Sardinops ocellata)

SEXUAL MATURITY AND REPRODUCTION
1950-54

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BY

D. H. DAVIES, Ph.D.

(Senior Professional Officer)

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I. Summary.

This paper is one of a series dealing with the general biology of the South African pilchard, *Sardinops ocellata* (Pappe), and is a study of the sexual maturity and reproduction of the pilchard during the period April 1950 to December, 1954.

A short introduction is followed by a description of the methods used for the collection of the data, after which each aspect of reproduction is considered separately. A section dealing with condition factor is also included.

The findings from this study are briefly as follows:—

(1) Spawning in the South African pilchard may take place to a limited degree throughout the year.

(2) The main spawning season of the pilchard extends from September to February.

(3) Within the period of main spawning there are apparent peaks of spawning activity; these peaks probably indicate the presence of prespawning fish in the commercial fishing area prior to their departure to the spawning grounds.

(4) Although spawning does take place in St. Helena Bay, the majority of fish move away from this area just prior to spawning. The area of main reproduction is not the area in which commercial catches of pilchards are made. A considerable amount of spawning takes place in the area of the offshore routine stations.

(5) Pilchards in the act of spawning are not normally caught by the commercial fishing boats.

(6) Ripening of gonads of pilchards does not take place simultaneously in all fish, but appears to occur in waves. As each group of fish approaches spawning condition it leaves the area.

(7) There is a relationship between the size of pilchards and the spawning season; small fish spawn early and large fish late in the season.

(8) The annual disappearance of pilchards from the St. Helena Bay area is linked with spawning, the months (winter) of highest incidence of pilchards in this area are the months of least gonad activity.

(9) There is an innate physiological rhythm of reproduction in the South African pilchard which causes the gonads of even immature fish to become enlarged during the spawning season although no spawning takes place.

(10) The ovary of a female pilchard of (standard) length 23·3 cm was found to contain 95,050 ova.

(11) The number of ova produced per female pilchard increases with the size of the fish.

(12) The estimated average number of ova spawned per female per season is 95,000 ova.

(13) The relationship between the weight and the length of the South African pilchard was calculated. For male fish the weight varies as the length to the power 2·928 and for female fish as the length to the power 2·808.

(14) A comparison between the California sardine and the South African pilchard showed that the sardine is a fish having less weight per unit of length than the pilchard.

(15) Condition or weight-length factor for the commercial catches of pilchards is high in summer, reaches a maximum in March, declines rapidly in autumn and winter to reach a minimum in August and September and begins to rise again in late spring.

(16) Condition factor was virtually the same for male and female pilchards from the commercial catches, irrespective of the size of fish or the season.

(17) Fluctuations in condition factor were not found to be directly related to feeding or reproductive activities.

(18) Condition factor is important to the industry as it shows a direct relationship to the fatness of the pilchard as indicated by its oil yield.

(19) At certain times of the year the flesh of pilchards becomes watery and soft; fish in this condition are known as *pap* fish and are unfit for either processing to fish-meal or for canning. This poor condition bears no relation to condition factor.

(20) The standard length of male and female pilchards at first maturity is at 18–18·5 cm Fifty per cent are sexually mature at ±19 cm and all pilchards are mature at 20·5–22 cm.

(21) The majority of fish comprising the commercial catches of pilchards in Union waters fall within length groups 21–24 cm and are sexually mature.

(22) The mean ratio of male to female pilchards in the commercial catches in the Union in all seasons is 44:56.

(23) The ratio of sexes varies with the size of the fish. Males predominate at 19–22 cm, females predominate from 22 cm upwards and beyond 22·5 cm nearly all the fish caught are females.

(24) The general relationship between the temperature of the 0–50 metres layer of the sea and gonad activity is an inverse one.

(25) Pilchard ova were found in the plankton at surface temperatures from 11·9 to 21·7°C.

(26) The largest concentrations of pilchard ova taken in the plankton were found under the following conditions: temperatures 14–16° C and salinities 35·1–35·4‰ at 0 metres, temperatures 13·8–15·8° C and salinities 35·1–35·4‰ at 10 metres and temperatures 13·8–16° C and salinities 35·1–35·36‰ at 20 metres depth.

(27) A temperature of 13° C was found to be the threshold temperature for major spawning.

(28) Temperatures of ± 15° C and salinities of ± 35·14‰ indicated average conditions most favourable for spawning.

Comparison of the Union and South West African Pilchards.

Although the data from South West Africa on pilchard research are limited to the findings of less than two years research on a small scale, a comparison of the findings is of paramount importance due to the strong likelihood that the two fisheries are connected. Due to the less complete nature of the data from South West Africa, the following findings must be treated as tentative:

(29) The general incidence of spawning and the period of maximum spawning activity of the pilchard appear to be the same for the Union and South West African waters.

(30) The commercial catches of pilchards in South West Africa consist mainly of smaller fish (standard length 19·5–22·5 cm) than those from the Union which consist mainly of lengths 21–24 cm.

(31) If the size at sexual maturity of the South West African pilchard is the same as that of the Union fish (see No. 20 above), (which is more than likely as detailed morphological examination and comparison of the two species has shown no differences), then a large proportion of the commercial catches in South West Africa consists of immature fish.

2. Introduction.

From the start of the pilchard research programme in April, 1950, it was realised that a full knowledge of the reproduction of the pilchard was of fundamental importance. Some mention of this aspect of the general biology of the fish has already been made in an investigation into the development and distribution of the eggs and larvae of the pilchard (Davies, 1954), but a more detailed study follows.

With the increasing knowledge of the South African pilchard it becomes more and more evident that the fish in many aspects of its biology and ecology is very similar to the California sardine *Sardinops caerulea* (Clark, 1934). Similarities in maturity and reproduction are no exception and are mentioned in this paper whenever encountered.

Incomplete data collected in 1947 indicated that the pilchard was sexually active during the spring and summer months and based on this data, it was decided to introduce a closed season in every year during what was thought to be the period of maximum reproductive activity. The reason for this decision was that it was thought wise to give fish some measure of protection during the reproductive season mainly in order that they could be allowed to spawn without being distrubed by the operations of the fishing boats. At the time it was felt that the little knowledge available was entirely inadequate as a basis for any conservational measures, but that any restrictions which might prevent permanent damage to the stocks should rather be made immediately and relaxed later. This principle of extreme caution in relation to unknown fish stocks has so far proved itself in the fisheries of the Union of South Africa and the policy of initially restricted exploitation which may be later relaxed in the light of new knowledge

gained will be continued. There are many examples of fisheries which had been over-exploited from the start and after a few years were no longer able to exist.

There is, however, no suggestion of complacency in the attitude towards the Union's fisheries and every possible effort is being made to gain a thorough biological knowledge of each important commercial species in order that scientifically sound measures of conservation may be applied.

Apart from establishing the extent of the spawning season of the pilchard in South African waters, the size of male and female fish at first maturity has been ascertained, and it has been shown that the minimum size of mesh permitted for the commercial pilchard nets is such that almost the entire catch consists of sexually mature fish.

Another factor of importance to the commercial fisheries which has been examined in relation to the reproductive activity of the pilchard is that of condition. The biological index of condition which is a weight-length relationship has been shown to be related to oil yield. The condition of pilchards known as *papness* in the factories, when fish are too soft and watery for processing may possibly be related to intensive reproductive activity.

Like the California sardine, the South African pilchard in not frequently caught with gonads in a ripe and running condition; in spite of this, however, gross or large scale observations of the gonads of all fish sampled, yielded very good information on reproductive activity. The study of the maturity of the California sardine by this method proved a failure (Clark, 1934).

The sexual maturity and reproduction of the pilchard have intentionally been examined from a number of different angles. The data so obtained have been combined and used to obtain *averaged* results, which are considered to be far better than results obtained from any single source of information.

The various methods used in this study are the examination and assessment of the state of gonads, the weight of gonads, the measurement of ova diameters, the collection of ova at sea, the calculation of condition factor and the effect of environmental factors on spawning. The findings from each of the above sources were amalgamated and the conclusions were drawn from the combination of data.

3. Methods.

(i) General.

The main commercial pilchard fishing grounds of the Union of South Africa lie off the West Coast and are centred in St. Helena Bay (see Fig. 1). Although most of the catches are made in the area bounded by Cape Columbine in the south, Rooiduinepunt in the north and extending 35 miles seawards from a point midway between the two, pilchards are sometimes caught farther south off Saldanha Bay, and in False Bay. Smaller numbers may also be caught off the coast of Natal during the month of June.

Regular sampling from the catches of commercial vessels was made from two field stations situated at Stompneusbaai and at Lambert's Bay (see Fig. 1) for the period March, 1950 to February, 1953 and at Stompneusbaai only through to the end of 1954. The Lambert's Bay field station was closed down in February, 1953 and the personnel doubled at Stomneusbaai shortly afterwards as it was found to be far easier to control and maintain contact with one station and also because it was easier to obtain samples from the commercial catches at Stompneusbaai.

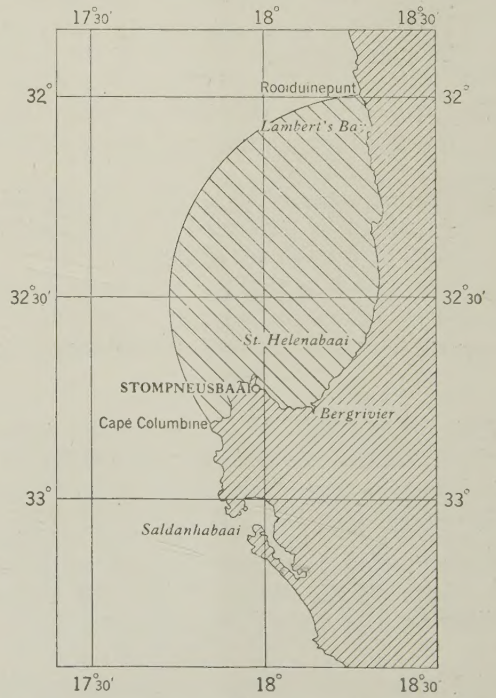


FIG. 1

MAIN COMMERCIAL FISHING GROUNDS

Trigsurvey, 1956 Government Printer, 1956

A sample consisted of 50 fish taken at random from the catch of a commercial fishing boat in the act of discharging its catch at the jetty. The sample was taken directly from the hold of the boat or from the centre of the pile of fish on deck by means of a scoop and placed in a large bucket. The time and position of catch were obtained from the skipper. The bucket usually contained about 60 fish and the first 50 were counted out to form the sample to be examined. It was unfortunately not possible to obtain fish from a number of boats, mix them in a single container and then take out a 50-fish sample, because during most of the period under review only one or at the most two boats could offload at a time alongside the jetty, and it would have been out of the question for the biologist to have spent a number of hours each day in the collection of a sample alone.

In practice, the biologist at each field station collected and worked one sample of pilchards every day that fish were caught and later when there was only one field station, each of the two biologists stationed there worked a 50-fish sample daily. This meant the examination of 100 fish on every fishing day. Fishing took place during the dark phases of the moon only and usually not on Saturdays and Sundays and was naturally prevented by bad weather so that the actual number of fish sampled each month varied considerably. Other factors such as the closed season and the disappearance of the fish at certain times added to the uncertainty of obtaining samples.

The treatment of the 50 fish sampled was briefly as follows:—

(1) The standard or body length from the tip of the snout to the end of the caudal peduncle (with the scales removed) was taken.

(2) The total length from the tip of the snout to the ends of the caudal fin pressed together so that the outer edges were parallel to the longitudinal axis of the body, was taken. Any fish with a distorted or broken caudal fin was discarded.

(3) The weight of the fish in the round was taken.

(4) The alimentary system was removed and examined in relation to feeding studies.

(5) The gonads were examined, given an index of sexual activity and weighed.

(6) A vertebral count of six fish per sample was made.

(7) Scales were removed and otoliths extracted from six fish per sample for age determination studies.

It is fully realised that this sampling procedure can at its best only provide data on the commercially-fished pilchards and not on the pilchard population as a whole. The efficacy of the above sampling procedure will be discussed in a later report. A great deal of supplementary data have, however, been provided by the sampling of young fish, not normally caught by commercial boats, and obtained by other methods such as seine nets, explosive charges and the examination of the stomachs of predatory fish and birds (Davies, 1955). These data have naturally not been obtained on such a regular basis as those of the sampling of commercial catches but have nevertheless proved a valuable supplement to the latter.

(ii) Examination of Gonads.

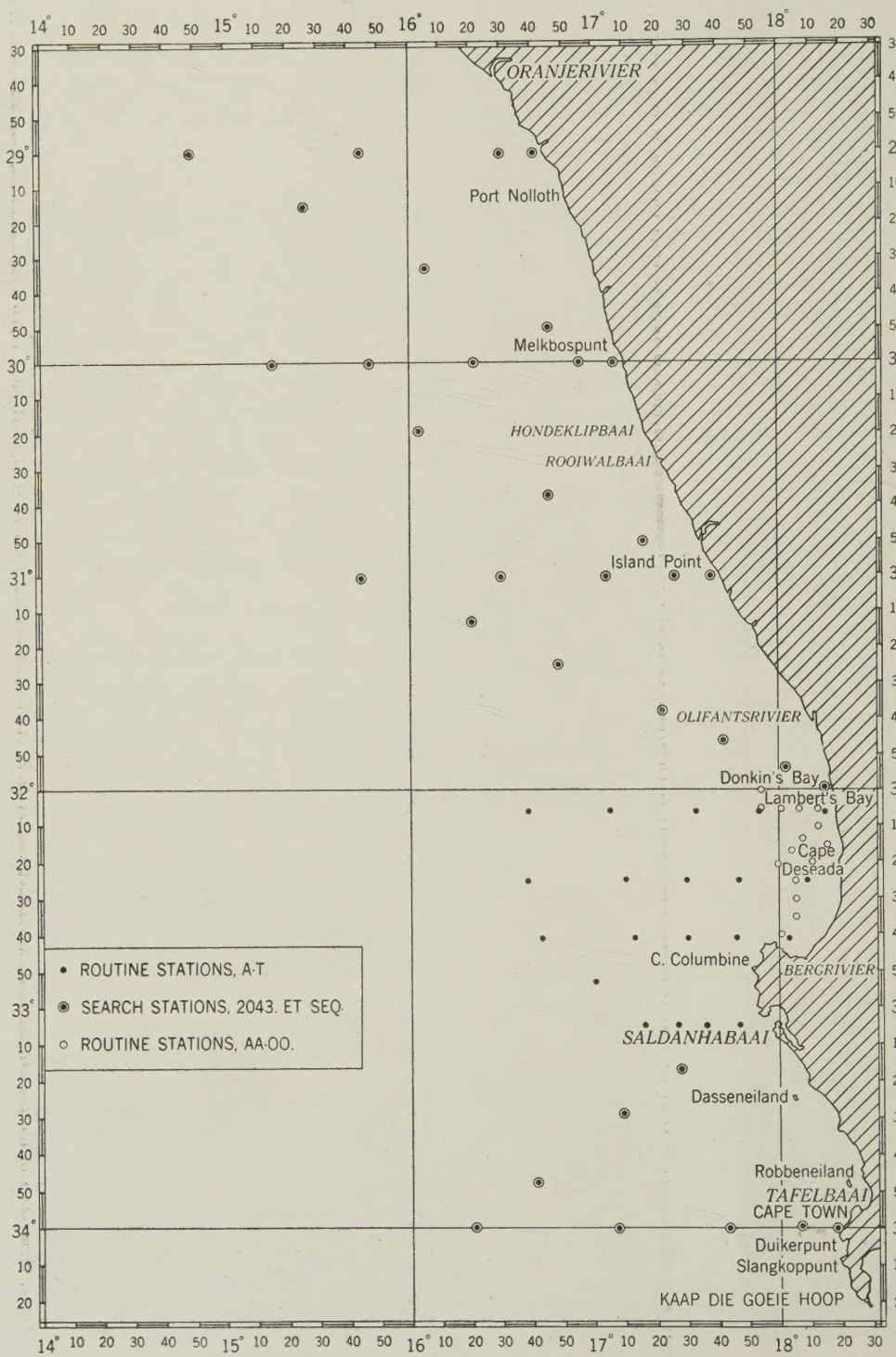
During the normal sampling of commercial catches the gonads of all fish were examined and assigned an index of sexual activity. This assessment of gonad activity was made in accordance with the stages of maturity described below.

The gonads were then removed from the fish and weighed accurately to 0·1 gm. Although weighing is by no means a standard procedure in work on the reproduction of fishes it was felt that it might be of value as an index of maturity.

(iii) Measurement of Ova Diameters.

For a period of one year measurements of the ova diameters of female pilchards were taken. The posterior region of the ovaries of at least the first five female fish of the sample was removed, placed in 5 per cent formalin and left for two days to harden. Parts of these were then spread out on a microscope slide with the aid of a dissecting needle and the diameters of the ova measured by means of a micrometer eyepiece attached to a microscope. Due to the shrinking action of the formalin a certain amount of distortion occurred and the ova were frequently not spherical. This gave diameter measurements which varied with the angle at which

FIG. 2



OFFSHORE ROUTINE (A-T), INSHORE ROUTINE (AA-OO)
AND WEST COAST SEARCH STATIONS (2043-)

Trigsurvey, 1956

Government Printer, 1956

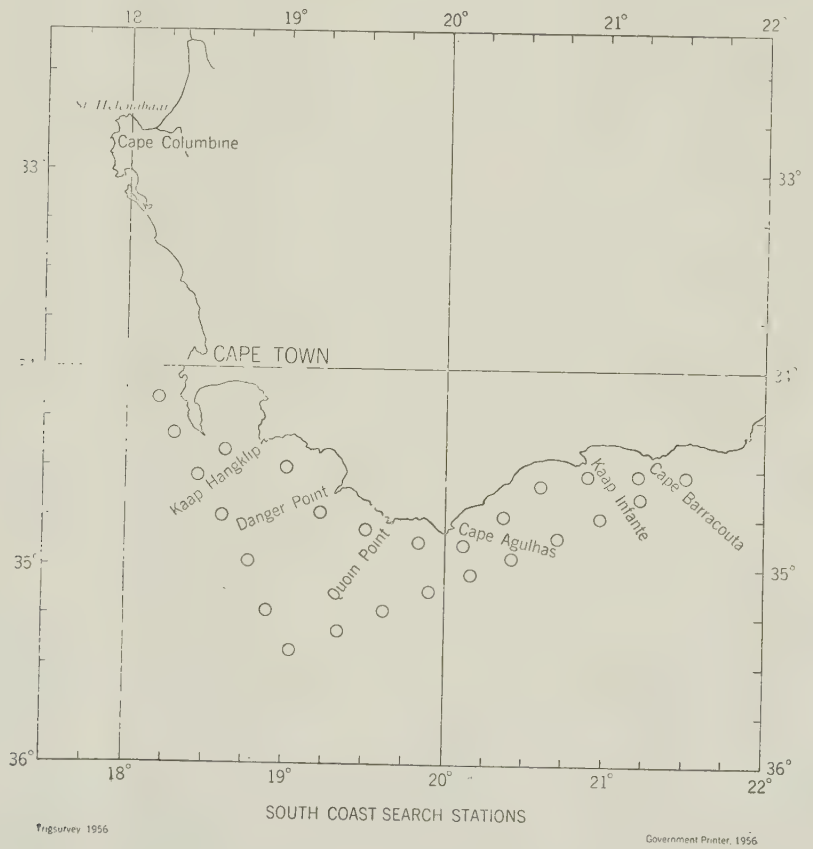
the reading was taken. The same procedure as that used by Clark (1934) was therefore adopted, i.e. the micrometer was placed in a horizontal position in the eyepiece and the diameters of ova parallel to the graduations on the micrometer were measured. This gave readings of long and short diameters at random.

It was felt that the distortion caused by the action of the preservative affected all ova in the same manner and to the same degree, as 5 per cent formalin was used for all ova and a standard time of two days was allowed to elapse before measurement was carried out.

The posterior region of the ovary was used in all cases due to the fact that the development of ova appeared to start in this region, and was usually in a more advanced state there than in the rest of the gonad. Unless excessive variation occurred in measurements, 50 ova from each gonad were measured.

During some months ova diameters of as many as 65 fish were measured, but at other times when pilchards were scarce or during the closed season, ova diameters were measured from only one individual. The overall measurements of ova for the year are considered to be a fair representation.

FIG 3



(iv) Collection of Ova at sea.

The collection of pilchard ova in relation to developmental studies, spawning surveys and the location of breeding grounds was carried out by the three vessels of the Division with standard plankton nets (Davies, 1954).

The operation of these nets was carried out in four areas, the offshore routine area (see Fig. 2, routine stations A–T), the inshore routine area (see Fig. 2, routine stations AA–OO), the West coast search area (see Fig. 2, search stations 2043–) and the South coast search area (see Fig. 3).

At each station an N70V plankton tow-net was hauled from 100–0 metres or 5 metres from the bottom to the surface, an N100H plankton tow-net was towed for 10 minutes and an N100B plankton

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tow-net was towed obliquely from 150–0 metres. During the period under review extra nets were used from time to time and the use of some nets discontinued, but all ova counts have been expressed in terms of a total count for the three nets N70V, N100H and N100B per station per month. If a particular station was occupied say three times a month, then the total number of ova obtained from the above nets for the station for the month was divided by three.

(v) Condition Factor.

The condition or weight-length factor K derived from the formula $K = \frac{100w}{l^3}$ (where w = weight in grams and l = total length in centimetres) was calculated for all fish. For a period of one year two variations of the normal K were calculated, viz. $K_1 = \frac{100w_1}{l^3}$ (where w_1 = weight of fish with alimentary system removed) and $K_2 = \frac{100w_2}{l^3}$ (where w_2 = weight of fish with alimentary system and gonads removed).

The relationship between condition factor, gonad activity and the oil content of the pilchard was examined, an indication of the oil content of the pilchard having been obtained from the mean returns of the oil yield of the pilchard catches provided by the West coast factories.

4. Stages of Gonad Activity or Maturity.

(i) Definition of terms.

In the assessment of the state of activity, condition or maturity of the gonads of fish, confusion invariably arises due to the indiscriminate use of the words *immature* and *mature*. The term immature implies that the gonad is undeveloped or inactive and belongs to a juvenile fish which has not yet reached its first sexual maturity, but on the other hand it is often assigned to the gonads of adult, sexually mature fish with inactive gonads but which may have spawned many times before.

During the examination of gonads of pilchards in the field, it was not known at what stage the fish became sexually mature and for this reason two main states of gonad activity were recognised, viz. *inactive* and *active*. The inactive gonads included those of immature and mature fish. The term mature was used later when the size at sexual maturity became known. Any fish below this size could then be assigned to the category inactive/immature.

(ii) The Stages.

Altogether ten stages of gonad activity for male and female fish were recognised, and these were represented on the sample sheets by means of the symbols *i*, *a*, etc. The stages are as follows:—

Stage 1. *i* = inactive.
,, 2. *ia* = inactive/active.
,, 3. *a* = active.
,, 4. *ar* = active/ripe.
,, 5. *r* = ripe.
,, 6. *rr* = ripe/running.
,, 7. *s* = spent.
,, 8. *si* = spent/inactive.
,, 9. *sia* = spent/inactive/active.
,, 10. *sa* = spent/active.

In some cases it was found extremely difficult to assign a gonad to any single stage of activity and it was for this reason that the combined stages 2, 4, 6, 8, 9, and 10 were added to the four stages originally used. For example, a gonad obviously spent but becoming clear of blood and in which resorption had taken place to a large extent so that it was well on its way to reverting to an inactive condition, was designated *si*.

The following is a brief definition of each stage of gonad activity, together with an approximate weight range for male and female fish. The weight range can only be very much an approximation when not confined to single size groups of fish.

Stage 1.—*i* = *inactive*—ovaries either immature or inactive, less than half the length of the body cavity, cylindrical but thin, pale pink in colour or transparent. Testis flat and leaf-like, pink or transparent.

Approximate weight:

Female..... 0·2–5·5 gm.
Male..... 0·2–4·5 gm.

Stage 2.—*ia* = *inactive/active*—ovaries inactive generally, but with the beginnings of enlargement taking place. Slight elongation, thickening and darker colouration; mainly translucent pinkish yellow. Testis beginning to thicken and become elongated with slight white colouration.

Approximate weight:

Female..... 2–7 gm.
Male..... 2–6 gm.

Stage 3.—*a* = *active*—ovaries elongated and filling over half the body cavity. Colour opaque yellow with discrete pigmented ova present. Testis elongated, thickened and filling over half the body cavity. Colour opaque white with crenellated edges.

Approximate weight:

Female..... 3–17 gm.
Male..... 2–15 gm.

Stage 4.—*ar* = *active/ripe*—ovaries elongated, distended, filling approximately two thirds of the body cavity. Colour bright yellow, gonads vascular, ova discrete and becoming transparent at posterior end. Testis further enlarged, filling approximately two thirds of the body cavity. Colour opaque white; milkiness apparent at posterior end.

Approximate weight:

Female..... 6–20 gm.
Male..... 5–18 gm.

Stage 5.—*r* = *ripe*—ovaries at maximum size, almost filling the body cavity. Colour darker yellow, no longer opaque but semi-transparent due to even dispersal of ripe ova throughout the gonad. Testis at maximum size, almost filling the body cavity. Colour opaque white; posterior half of gonad milky.

Approximate weight:

Female..... 10–30 gm.
Male..... 9–28 gm.

Stage 6.—*rr* = *ripe/running*—really the same as stage 5, except that perhaps greater enlargement has taken place and pressure on the belly causes extrusion of ova or milt through the vent. Fish in this condition almost in the act of spawning.

Approximate weight:

Female..... 12–35 gm.
Male..... 10–30 gm.

Stage 7.—*s* = *spent*—ovaries elongated, but flat due to recent evacuation of ova, very bloodshot, sometimes gelatinous. Testis elongated, flat, strap-like and very bloodshot.

Approximate weight:

Female..... 1–7 gm.
Male..... 1–6 gm.

Stage 8.—*si* = *spent/inactive*—ovaries much like those of previous stage, but obvious signs of recovery and reversion to stage 1, i.e. further shrinkage, less bloodshot in appearance and beginning to become transparent. Testis—as for ovaries.

Approximate weight:

Female..... 2–7 gm.
Male..... 2–6 gm.

Stage 9.—*sia* = *spent / inactive / active*—ovaries showing signs of having been recently spent, recovery to stage 1 apparent, nevertheless evident that reversion to stage 1 is only temporary as signs of "making" to stage 3 already evident. Testis—as for ovaries.

Approximate weight:

Female..... 4–10 gm.
Male..... 3–8 gm.

Stage 10.—*sa* = *spent/active*—ovaries still showing signs of having been recently spent, but evidence that gonads are about to become active almost immediately by "making" to stage 3. Testis—as for ovaries.

Approximate weight:

Female..... 2–5 gm.
Male..... 2–4 gm.

It was found in practice that the use of symbols was far more satisfactory than numbers, and the various stages were only given numbers for convenience in writing up the data. The reason for this is that the letters of each symbol stand for the state of the gonad e.g. *s* = *spent*, *rr* = *ripe/running* and from the beginning of the examination of samples there was never any need to remember numbers or refer to a key.

5. Gross Assessment of Gonad Activity or Maturity.

During the period April, 1950 to December, 1954 a total of 13,331 male and 18,410 female pilchards was examined in detail from the samples taken at random from the commercial catches. Plates 1–10 and Tables 1–10 illustrate the mean state of gonad activity or sexual maturity for all fish per month, male and female fish having been treated separately. The following is a brief resumé of gonad activity on a seasonal basis for each year:—

(i) Male Pilchards 1950–1954.

1950 Males (See *Plate* 1).

(a) *Autumn.*—During April and May the majority of pilchards possessed inactive (stage1), active (stage 3) or spent* (stage 7) gonads. A very small number (3·8 per cent) were at stage 4, i.e. active to ripe and a single male ripe and running (stage 6).

(*b*) *Winter.*—During June and July the majority of fish were at stage 1 (inactive) with most others at stages 2 and 3, viz. passing from the inactive to the active stage or in the active stage. Very small numbers (1·3 per cent) of stage 4 fish in the month of June increased to 2·8 per cent of active to ripe fish in July. A single stage 6 male was found in June.

In August, however, fewer fish were at stage 1, fewer still at stage 2 and signs of generally increased gonad activity were seen in larger numbers of fish at stages 4 and 5 and in two males at stage 6.

(*c*) *Spring.*—September, October and November were characterized by the decrease in numbers of stage 1 and 2 males and the marked increase of stage 3 or active fish. This was accompanied by larger numbers of stage 4, 5 and 6 fish.

(*d*) *Summer.*—In December hardly any (2·2 per cent) inactive males were obtained and the majority (68·9 per cent) were at stages 4, 5 and 6 with one fish spent.

1951 Males (See *Plate* 3).

(*a*) *Summer* (continued).—In January no inactive males were found, the majority (70 per cent) being at maximum gonad activity stages 4, 5 and 6. During this month maximum gonad activity for male fish was thus recorded.

February showed a majority of stage 3 (40·8 per cent) fish together with a high percentage of stages 4 and 5 (38·8 per cent). Small numbers of spent and inactive males appeared.

(*b*) *Autumn.*—During March stages 3, 4 and 5 still predominated and larger numbers of inactive and spent males appeared. In April, however, stages 4, 5 and 6 fell to 10·3 per cent while spent and stage 1 and 2 males increased considerably. May showed a very marked decrease of stages 4, 5 and 6 represented by a single stage 4 fish.

(*c*) *Winter.*—June was characterized by a complete absence of stage 4, 5 or 6 fish and the presence of mainly stages 1 and 2 together with smaller numbers of stage 3 males. June could therefore be classified as the month of least activity for pilchard males. In July a well marked reversal occurred in which the majority of males were in stages 2 and 3, i.e. the stage 1 fish of June became active to form the stages 2 and 3 of July. Small numbers of stage 4, 5 and 7 were recorded. In August the development of stage 1 and 2 males to stage 3 fish was clearly shown together with a marked increase of stages 4 and 5 (26·5 per cent).

(*d*) *Spring.*—By September stages 1 and 2 had fallen to a minimum (2·4 per cent) and stage 3 (42·2 per cent) although high, had been overtaken by stages 4 and 5 (55·4 per cent). Unfortunately no data were collected during October due to the closed season for commercial fishing. In November stage 3 males dominated the catches followed by stage 4 (23·1 per cent) and 5 (7·7 per cent) fish.

(*e*) *Summer.*—During December stage 3 fish were still dominant but more stage 5 fish (23·2 per cent) were present than in the previous month.

* Special stage 10 gonads such as *si, sia,* etc. included with stage 7.

1952 Males (See *Plate* 5).

(*a*) *Summer* (continued).—In January stage 3 males were still dominant (63·6 per cent) and stages 4 and 5 common (25·8 per cent). In February the position remained the same except for the presence of small numbers of spent fish, and an increase in numbers of stage 1 males (17·1 per cent).

(*b*) *Autumn.*—Further increase in the numbers of stage 1 fish (43·2 per cent) together with a decline in numbers of stage threes (35·9 per cent) occurred in March. Small numbers of spent fish were recorded in each month of autumn. In April the majority (81·4 per cent) of males were in stage 1 or 2, and in May the position was much the same (stage 1 and 2–90·5 per cent). Small numbers of stage 3 fish were present during each month.

(*c*) *Winter.*—In June no stage 4, 5 and 6 males were recorded and the catch consisted mainly of stage 1 and 2 fish (75·5 per cent) with some (23·8 per cent) stage 3 fish present. Three spent fish were recorded. This month could be regarded as the month of least sexual activity for male pilchards. July was generally like June except that there was a decline in stage 1 fish, an increase in stage 3 and small numbers of stages 4, 5 and 7 were recorded. In August marked increased activity was shown by further decline in numbers of stage 1 and 2 fish and marked increase of stage threes (50·8 per cent) and stage 4 and 5 males (25·1 per cent).

(*d*) *Spring.*—In September only two fish were obtained, both of which were at stage 1. In October larger numbers reflected similar conditions as for August viz. much increased gonad activity. These two months were, however, closed for commercial fishing and sampling was consequently quite unsatisfactory. During November the majority of males were at stage 3 (60·6 per cent) and a large number at stages 4 and 5 (36·1 per cent) showing that a steady increase in gonad activity had probably taken place during the spring months.

1953 Males (see *Plate* 7).

(*a*) *Summer.*—Unfortunately no data were obtained during December, 1952, but January, 1953 again showed a majority of stage 3 (59·1 per cent) and a fair number (9·1 per cent) of stage 4 fish to be present. February was the month of maximum gonad activity with 54·3 per cent of stage 3 and 43·7 per cent of stage 4 and 5 males.

(*b*) *Autumn.*—During March the number of stage 3 fish was almost the same as for the previous month (57·4 per cent) but a decrease in stages 4 and 5 (21·7 per cent) occurred. In April no stage 4, 5 or 6 males were recorded and gonad activity was characterized by the presence of a majority of stage 1 and 2 (86·2 per cent) fish. May was the month of least activity and stage 1 and 2 males formed 94·6 per cent of the catches, the other 5·4 per cent of fish being at stage 3.

(*c*) *Winter.*—The month of June was similar to May in that most gonads were inactive, but a marked development of stage ones into stages 2 and 3 was shown. This development was more pronounced in July and stage 3 fish increased to 45·2 per cent. In August increased gonad activity was striking and stage 3 males reached 63·4 per cent and small numbers (1·5 per cent) of stage 4 fish appeared.

(*d*) *Spring.*—September was similar to August, but in October spent fish made their appearance. Results for November did not reflect the normal commercial catches as this month was closed for fishing. It is of interest to note, however, that a single stage 5 fish was obtained.

(*e*) *Summer.*—December was also a closed season month and the large numbers of stage 1, 2 and 3 males were below the size normally caught by the fishing boats.

1954 Males (see *Plate* 9).

(*a*) *Summer* (continued).—In January stage 3 males (78·4 per cent) were recorded in far greater numbers than any other category, others being some stage 4 (18·1 per cent) and

a single stage 5 fish. In February almost all the males examined were stage 3 (96·5 per cent) fish.

(*b*) *Autumn.*—In March stage 3 fish (82·0 per cent) still dominated the catches, some (8·6 per cent) stage 4 and a few stage 1 and 2 fish being also present. During April the numbers of stage threes decreased to 30 per cent, stage fours increased to 10·5 per cent and inactive fish in stages 1 and 2 increased to 59 per cent. In May the majority of males were at stages 1 and 2 (75 per cent) and stage threes had declined to 23·4 per cent.

(*c*) *Winter.*—June showed a majority of stage 1 and 2 fish (54·8 per cent), an increase in stage 3 (42·9 per cent) and the presence of some stage 4 (1·8 per cent) fish. In July stages 1 and 2 had decreased to 26·3 per cent and stage 3 increased to 71·7 per cent. A few stage 4 males were recorded. During August stage 1 and 2 fish again increased in numbers and stage threes decreased. A small number of spent fish appeared.

(*d*) *Spring.*—In September stage 1 and 2 males increased in number and spent fish again appeared. During October, however, stage 3 fish increased in number up to 76·1 per cent, the rest consisting of smaller numbers of stage 1 and 2 fish together with some stage fours (8·1 per cent). In November all fish were active, i.e. at stage 3 (87·3 per cent) or 4 (10·9 per cent).

(*e*) *Summer.*—Although the samples for December were obtained in False Bay it is of interest to note that the state of gonad activity for male fish was almost identical to that of November fish from St. Helena Bay. Of these males 97·2 per cent were at stage 3 and 2·8 per cent at stage 4.

(ii) Female Pilchards 1950–54.

1950 Females (see *Plate* 2).

(*a*) *Autumn.*—During April the majority of females were spent* (60·9 per cent) with small numbers at stages 1 (22 per cent) and 3, 4 and 5 (17·1 per cent). In May the position was almost the same.

(*b*) *Winter.*—During June the largest number of recordings was of inactive females at stages 1 and 2 (71·2 per cent) but small numbers of stages 3, 4 and 5 were present and 16·2 per cent of spent fish. In July the position was similar except that there were fewer spent fish. During August the numbers of stages 1 and 2 fish decreased and there was a marked increase of stages 3, 4 and 5 (42·9 per cent).

(*c*) *Spring.*—A further decline in stages 1 and 2 and a greater increase in stages 3, 4 and 5 took place in September and continued in October, when a stage 6 female was obtained. The position in November was similar and spent fish were present in all months. More stage 5 females (12 per cent) were recorded in November.

(*d*) *Summer.*—In December greatest gonad activity was shown by the presence of 89·9 per cent of stage 4 and 5 females. Very small numbers of stages 1, 2 and 3 were also recorded.

1951 Females (see *Plate* 4).

(*a*) *Summer* (continued).—During January most females (89·1 per cent) were at maximum gonad activity stages 4, 5 and 6. Three ripe and running females were obtained. In February 40·8 per cent of fish were at stage 3 and 40·2 per cent at stages 4, 5 and 6.

(*b*) *Autumn.*—During March stages 3, 4 and 5 predominated, but in April the largest number of fish belonged to stages 1, 2 and 7, i.e. inactive and spent fish. In May 86·7 per cent of all fish were at stages 1 or 2 and a few (8·9 per cent) spent.

(*c*) *Winter.*—In June most females (86·4 per cent) were at stages 1 and 2 and very small numbers at 3, 4 and 7. During July a decrease in stages 1 and 2 and an increase in stages 3 and 4 occurred. In August most fish were in the active stages 3, 4 or 5. Small numbers of spent fish were present in all three months.

(*d*) *Spring.*—In September 50·9 per cent of females were at stage 3, and 39·3 per cent at stages 4 and 5. No data were available for October due to the closed season, but November showed a greater percentage of stage 4 fish (49 per cent).

* Special stage 10 gonads such as *si, sia,* etc., included with stage 7.

(*e*) *Summer.*—December presented a similar picture to November but larger numbers (12·1 per cent) of stage 5 fish were present.

1952 Females (see *Plate* 6).

(*a*) *Summer* (continued).—During the remainder of the season the numbers of females in stages 3, 4 and 5 remained approximately the same i.e. mainly stage 3 fish but fair numbers of stage fours and some stage fives. A few spent fish appeared in February.

(*b*) *Autumn.*—In March far more stage 1 fish (40·3 per cent) were recorded and there was a decline in stages 3, 4 and 5. Spent fish increased considerably (20·8 per cent). During April the majority (64·7 per cent) of females were at stage 1 with very few at stages 3, 4 and 5 and a further increase of spent fish (27·3 per cent). May showed a similar but stronger trend towards inactivity than April. Most fish (60·2 per cent) were at stage 1, and virtually all others were spent fish (35·2 per cent).

(*c*) *Winter.*—In June most fish (67·6 per cent) were at stages 1 and 2, although signs of activity were indicated by the presence of 14·6 per cent of stage threes. The numbers of spent females showed a decrease from the previous month (17·4 per cent). During July stages 1 and 2 were being replaced by the active stages 3, 4 and 5 and a very high percentage (9·1 per cent) representing 68 fish in stage 6 were obtained. This development was generally followed in August except that no stage 6 fish were obtained.

(*d*) *Spring.*—Results obtained for September and October are not considered to be reliable as only 38 fish were obtained due to the closed season. These fish were mainly at stages 3 and 4. November showed the majority of fish (61·6 per cent) to be at stage 3 and a large number at stages 4 and 5 (30·7 per cent).

1953 Females (see *Plate* 8).

(*a*) *Summer.*—Unfortunately no data were obtained during December 1952, but January 1953 showed that a fair number of stage 1 fish (48·2 per cent) had appeared but that the majority consisted of stages 3 and 4 females (51·8 per cent). In February most fish were in the active stages 3, 4 and 5 (96·5 per cent) with very few at stage 1. This month was characterized by the appearance of stage 7 fish.

(*b*) *Autumn.*—March was again a month of great gonad activity, most fish being at stages 3, 4 or 5. There was an increase over the previous month of stages 1 and 7. April showed a reversion to the inactive stages—stages 1 and 2 (32·6 per cent) and the presence of spent fish (8·3 per cent). During May even less activity was recorded and 91·7 per cent of fish belonged to stages 1 and 2, 5·6 per cent to stage 7 and only 2·8 per cent of fish were at stages 3 or 4.

(*c*) *Winter.*—June was recorded as a month of little gonad activity; stages 1 and 2 (78·6 per cent) being in the majority. A small number of spent fish were present. During July gonads were still mainly inactive, i.e. at stages 1 and 2 (57·7 per cent) but a definite development to stages 3, 4 and 5 (42·4 per cent) was evident. The position was much the same in August as it was for July.

(*d*) *Spring.*—In September stage 4, 5 and 6 females (3·2 per cent) were recorded together with small numbers (3·2 per cent) of spent fish. In October and November which were closed season months, results are not considered to be reliable, but it is important to note that five stage 6 females and numerous spent fish were obtained in October.

(*e*) *Summer.*—In December the season was also closed and the results are therefore not a reflection of commercial catches. The majority of fish were at stages 1 and 2 although small numbers of stage 4 and spent fish were recorded.

1954 Females (see *Plate* 10).

(*a*) *Summer* (continued).—In January the majority of fish were at stage 3 (82·1 per cent) with very few at stage 4 (2·7 per cent) and some (3·8 per cent) spent. February was the same except that no spent fish were recorded. Stage 1 fish were recorded.

(*b*) *Autumn.*—In March most fish (71·4 per cent) were at stage 3, only one fish at stage 4 and two at stage 7. The number of females at

stage 1 had increased to 16·1 per cent. April produced an increase in stage 1 fish to 69·3 per cent and showed a decrease of stages 3 (7·9 per cent) and 4 (0·4 per cent). Spent fish (8·3 per cent) were present. In May stage 1 fish were dominant (84·8 per cent) with other stages such as 2, 3, 4 and 7 present. May was therefore a month of little gonad activity.

(*c*) *Winter.*—June was characterized by the presence of mainly inactive fish at stages 1 and 2 (85·8 per cent) although small numbers of stages 3, 4 and 5 (14·2 per cent) females were recorded. In July the position had become altered and stage one fish had decreased and stage 3 and 4 increased to 32·2 per cent. Spent fish (2 per cent) appeared. In August the position was similar except that more spent females (10·6 per cent) had appeared.

(*d*) *Spring.*—During September fish were mainly inactive; spent females (3·5 per cent) were recorded. Greater activity was shown in October where stage 3 (53·7 per cent) was dominant. Larger numbers of spent fish (7·3 per cent) were present. In November, most fish (95·8 per cent) were at stage 3 and three individuals were recorded at stage 6.

(*e*) *Summer.*—Samples of fish were obtained only from False Bay in December and the majority of gonads were at stage 3 (78·9 per cent). A fair number (17·5 per cent) were, however, recorded at stages 4 and 5 and some spent fish (3·5 per cent) were present.

(iii) Summary of Gonad Activity.

The following is a summary of gonad activity of male and female pilchards combined in relation to the gross examination of gonads.

1. 1950—

Autumn..	April—gonad activity declining rapidly; mainly spent fish.
	May—reverting to stage 1.
Winter...	June—gonad activity very low.
	July—gonad activity very low.
	August—gonads beginning to make.
Spring...	September—gonad activity intense; stage 6 males recorded.
	October—gonad activity intense; stage 6 females recorded.
	November—gonad activity intense.

2. 1951—

Summer..	December 1950—maximum gonad activity.
	January—maximum gonad activity.
	February—gonad activity intense; beginning of decline.
Autumn..	March—general decline of gonad activity.
	April—general decline of gonad activity.
	May—general decline of gonad activity.
Winter...	June—gonad activity very low.
	July—sudden making of gonads to
	August—intense gonad activity.
Spring...	September—gonad activity intense.
	October—no data.
	November—gonad activity intense.

3. 1952—

Summer..	December, 1951—gonad activity intense.
	January—gonad activity intense.
	February—gonad activity intense; beginning of decline.
Autumn..	March—gonad activity high, but on the decline.
	April—declining rapidly.
	May—gonad activity very low.
Winter...	June—gonad activity low.
	July—sudden burst of intense activity; stage 6 females recorded.
	August—gonad activity fairly intense.
Spring...	September—data unreliable.
	October—data unreliable.
	November—gonad activity fairly intense.

4. 1953—

Summer..	December, 1952—no data.
	January—gonad activity fairly intense.
	February—gonad activity fairly intense; beginning of decline.
Autumn..	March—gonad activity less intense, further decline.
	April—gonad activity low, declining.
	May—gonad activity very low, declining.
Winter...	June—gonad activity very low; beginning of new activity.
	July—gonad activity low, continued new activity.
	August—gonad activity increasing in intensity.
Spring...	September—gonad activity fairly intense.
	October—gonad activity intense.
	November—no data.

5. 1954—

Summer..
- December, 1953—False Bay only; gonads active.
- January—gonad activity fairly intense.
- February—gonad activity fairly intense.

Autumn..
- March—gonad activity fairly intense.
- April—gonad activity fairly intense; beginning to decline.
- May—gonad activity low.

Winter...
- June—gonad activity mainly low, small numbers active.
- July—gonad activity mainly low, small numbers active and spent.
- August—gonad activity mainly low, some spent.

Spring...
- September—gonad activity low.
- October—gonad activity intense.
- November—gonad activity intense.

Summer..
- December—False Bay, gonad activity fairly intense.

(iv) State of Gonads and Spawning.

(*See Fig.* 4, *Plate* 11, *Figs* 1 *and* 2 *and Tables* 11 *and* 12.)

Having assessed the state of gonad activity or maturity of all pilchards sampled over a period of nearly five years, it is possible to consider what indications these data provide in relation to the spawning season of the pilchard. A simplified chart of gonad activity was prepared to show when spawning took place during each year (see Fig. 4).

From this it is seen that during 1950 autumn was apparently a post-spawning period in which spent fish and fish declining to stage 1 were in the majority. Winter was the season of least reproductive activity except that towards the end of winter gonads began to make again. In spring spawning began with ripe and running females recorded in October, and continued through the summer of 1950/51 with more ripe and running female fish in January and February.

During the autumn of 1951 fish were mainly declining or spent and at the beginning of winter reproductive activity was at its lowest. Gonads were on the make again in July and were intensely active by August. Gonads were intensely active throughout the spring months but no ripe and running females were obtained. This activity continued through to the end of summer 1951/52.

During the autumn of 1952, fish were at first spent and then declined to become inactive in May. They remained inactive during June, the first month of winter, after which there was a sudden jump up to intense activity and spawning with ripe and running females present. This was the beginning of the period of intense gonad activity which lasted through until the end of summer 1952/53.

During the autumn of 1953 fish were spent, declining and then inactive by May. They remained inactive in June but were on the make during the other two months of winter. Intense gonad activity and spawning took place in September and October and intense gonad activity continued through to March, the first month of autumn, 1954.

During the autumn of 1954 fish were at first spent and then declined to become generally inactive in May. This low activity lasted until June and during the remaining two months of winter gonads were on the make. In early spring gonads were inactive and on the make, but in October and November intensive activity and spawning was recorded. During December gonads were still intensely active.

It is significant that during a period of four years and nine months of intensive sampling of the commercial catches of pilchards, only 108 ripe and running female pilchards were obtained. It can therefore be stated that *pilchards in the act of spawning are not normally caught by commercial fishing boats.* This may be due to the fact that they move to greater depths or migrate and are absent from the area of catching. It is more than likely, however, that pre-spawning pilchards move away from the St. Helena Bay area and go deeper. In spite of this, it is considered that the recordings of the state of gonads of pilchards throughout the year give a very good indication of the spawning season.

The *extent* of the spawning seasons according to gonad activity may therefore be defined as follows:—

1950–51 September–February

1951–52 August–February

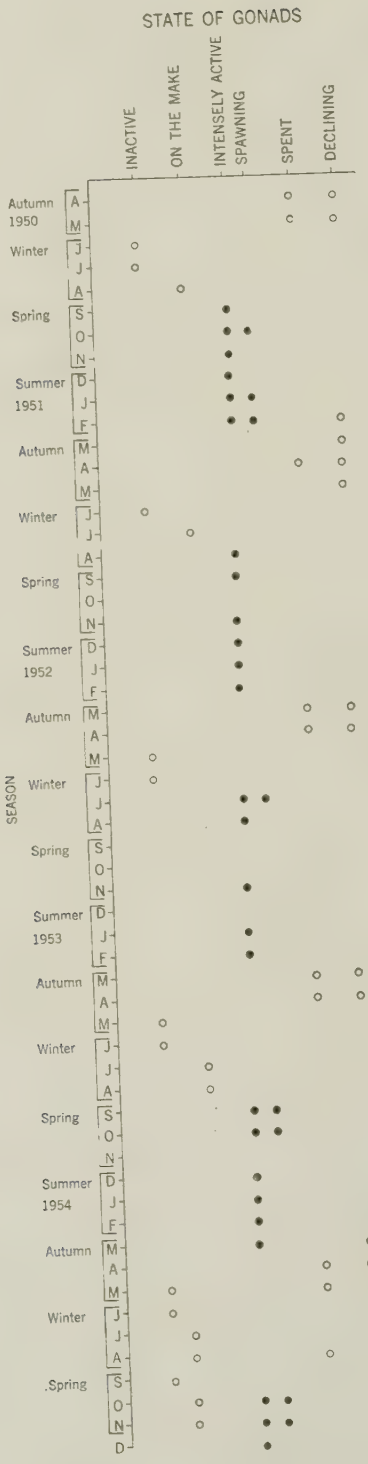
1952–53 July–February

1953–54 September–March

1954–55 Began in October.

135720—3

FIG. 4



SIMPLIFIED CHART OF GONAD ACTIVITY OF PILCHARDS TO SHOW SPAWNING SEASON.

Government Printer, 1956.

Treasurvey, 1956.

The above periods vary in length from six to eight months, i.e. spawning may take place during two thirds of the year. It is considered that within each period there is a shorter period of intensive spawning. Previous to this a *build up* occurs and after the shorter period a decline sets in. During both build up and decline a certain amount of spawning occurs with the result that an impression is gained of a very protracted spawning season.

When pilchard gonads at stages 4, 5 and 6 are plotted graphically (see Plate 11, Figs. 1 and 2) the mean period of maximum gonad activity is seen, which shows that the spawning period may extend from July through *to April, but the main spawning takes place between September and February.*

There is no doubt that spawning may start early in one year e.g. July 1952 and late in another e.g. October 1954 and the overall extent appears to vary by one or two months.

6. Size at Sexual Maturity.

(i) General.

In a commercial fishery it is important to know the size at which the fish become sexually mature for the first time, the size at which 50 per cent of the commercial catches are mature and the size at which all fish are sexually mature. Data on the gonad activity of pilchards were examined in relation to size at first maturity for the period 1950–54. Males and females were treated separately in the event of the possibility that male fish did not reach sexual maturity at the same size as females. Standard or caudal length was used as an index of the size of the fish.

Only data from the periods of maximum gonad activity or what was calculated to be the main spawning period were used so that the results were not masked by the more retarded gonad condition of late spawners or by the recovered gonads of early spawners. During the whole period, only the results for 1954 were unsatisfactory due mainly to the absence of fish with peak activity gonads in the commercial fishing area. Results for the other years are considered to be good, although they were also affected by the migration of spawning fish away from the area.

Hickling (1930) has stated that for the hake (*Merluccius vulgaris*) gonad development takes place even in fish which are not sexually mature, and that gonads may enlarge and develop to a kind of pseudo-maturity at the same time that adult fish gonads are developing for spawning. These *adolescent* gonads do not become fully ripe, however, and eventually regress. Clark (1934) was not able to prove or disprove this possibility for the California sardine, nor has it been possible to do so for the South African pilchard but, as will be shown later, it seems very likely that such development does take place. In order to take this possibility into account the data on gonad condition for the years 1952 and 1954 (see tables 17–20 and Plate 13, Figs. 1 and 2) were treated on a different basis from the years 1950, 1951 and 1953 (see Tables 13–16 and Plate 12, Figs. 1–4).

The basis (for convenience called basis A) used for the differentiation of immature and mature fish for the years 1950, 1951 and 1953, i.e. the normal basis, was as follows:—

Basis A.—Fish with gonads at stage 1 (*a*) at the peak of the reproductive season were regarded as immature and at stages 2–7 (i.e. *i*, *ia*, *a*, *ar*, *r*, *rr* and *s*) as mature.

The basis (for convenience called basis B) used for the years 1952 and 1954 in order to avoid the possible inaccuracies which would occur if Hickling's adolescent gonad development applied to the pilchard was as follows:—

Basis B.—Fish with gonads at stage 1 at the peak of the reproductive season were regarded as immature and at stages 4–7 as mature. In this manner any doubtful fish which might be adolescents with gonads developing to pseudo-maturity would be eliminated by discarding stages 2 and 3.

It is stressed that the results of this study on the size of the pilchard apply mainly to the fish comprising the commercial catches and not necessarily to the whole population. During the period February 1951 to November 1953, however, the gonads of all the catches of pilchards below the size of fish normally caught by the commercial vessels were examined. These fish were caught at various times and by various means by the research vessels of the Division. It was found that the gonads of all pilchards under a standard length of 16·9 cm were immature (see Table 21). The

percentage frequency of the sizes of pilchards in the commercial catches for the years 1950–54 shows a range of standard length of approximately 17–25 cm (see Plate 56).

(ii) The sizes at first Maturity.

(a) Male pilchards.

(1) No male pilchards smaller than 18 cm standard length (basis A), and 18·5 cm (Basis B) were found maturing.

(2) Fifty per cent of male pilchards were mature at length group 18·5–19·5 cm (Basis A) and 19·5–20·0 cm (Basis B).

(3) Almost all male pilchards were mature at length group 20·5–22·0 cm (Basis A) and 20·5–21·0 cm (Basis B).

(b) Female pilchards.

(1) No female pilchards smaller than 18·5 cm standard length (Basis A), and 18·5 cm (Basis B) were found maturing.

(2) Fifty per cent of female pilchards were mature at length group 19·0–20·5 cm (Basis A) and 19·5–20·0 cm (Basis B).

(3) Almost all female pilchards were mature at length group 20·5–22·0 cm (Basis A) and 20·5–21·0 cm (Basis B).

It appears therefore that the treatment of the gonad data on the A or B basis makes little difference except that for Basis A there is a slight extension of the range of length groups at which the various percentages of maturity occur. Until the question of the seasonal development of the gonads of adolescent pilchards without reproduction actually taking place has been proved or otherwise, these extended length groups can conveniently be used.

In brief therefore, it may be said that *the standard length of the South African pilchard at first maturity is between* 18–18·5 *cm for both male and female fish. Fifty per cent of males are mature at* 18·5–20 *cm and fifty per cent of females are mature at* 19·0–20·5 *cm. All pilchards are sexually mature at* 20·5–22 *cm.*

It is interesting to note the similarities between the South African pilchard and the California sardine. California sardine females mature for the first time at 16–17·0 cm, fifty per cent are mature at 18–19 cm and all are mature at 22 cm (Clark, 1934).

7. Gonad Weights.

During the period late March, 1950 to December, 1954, the gonads of all male and female pilchards sampled from the commercial catches were weighed. In all, the gonads of 31,741 pilchards were weighed during this period. Although the practice of weighing of gonads is not widely used as a means of assessing gonad activity, it was felt that the weight would act as a numerical complement to the visual assessment of the state of activity or maturity. In view of the fact that visual assessment could never be entirely standardized due to the personal factor, an additional means of assessment would, it was thought, be a valuable asset. In practice it was found that while gonad weight alone was not sufficient as an indicator of spawning and reproductive activity, it was a valuable accessory to the visual assessment of gonad activity.

Graphical representation of gonad weights per length group for male and female pilchards separately on a monthly basis from March, 1950 to December, 1954 may be seen in plates 14–27. All graphical data have been expressed in calendar years for convenience in comparing other data on the pilchard. This does not permit the illustration of the full reproductive cycle of the pilchard continuously, but a representation of the fluctuations of reproductive activity on a continuous basis during the period April, 1950, to December, 1954, is shown in Plate 57. As full details of the variations of weight in relation to season and length group are available in this form the following account has been made as brief as possible.

(i) 1950 (see *Plates* 14, 15).

(a) Male pilchards.

The gonad weights of the smaller males between 17·5–19·0 cm in length showed a slight tendency to rise in September; in the length group 19·0–19·4 cm gonad weights were highest in March and declined in April to reach their lowest weight in May. Then through from 19·5–21·4 cm there appears to have been little or no weight increase before July. This suggests that apart from the

instance in the 19·0–19·4 cm length group, spawning in the previous season finished early for these smaller males, or that males below 19 cm in length had not spawned before.

From 21·4 cm upwards gonad weights were fairly high in March and were probably still declining after the previous season's spawning. The decline continued and gonad weights were lowest in April and May. Gonad weights began to increase again in June; maximum gonad weights occurred from September to December with a suggestion of two peaks, one in September and the other in December.

Reproductive activity of male pilchards in 1950 as indicated by gonad weights began in June and continued through to December. In fish over 21·5 cm in length gonad weights were still high from the previous season's spawning. Maximum gonad activity occurred from September to December.

(b) Female pilchards.

The gonad weights of smaller females in length groups 17·5 to 20·0 cm showed little change in weight between March and December, 1950. Slight tendencies for increased gonad weight were recorded in November. Between the lengths of 20·0 and 22·0 cm gonad weights remained steadily low from March to June from when they rose through to December. Slight evidence of a peak in September and another in December was shown.

From lengths of 22 cm upwards females showed signs of the previous season's spawning as gonad weights were still fairly high in March, but were on the decline.

The period when lowest gonad weights were recorded was from April to June. Highest gonad weights for fish over 21·5 cm in length were recorded between August and December and the period of maximum gonad weight for all females was from September to December.

(ii) 1951 (*see Plates 16–18*).

(a) Male pilchards.

In the lower length groups of 17·5–19·0 cm gonad weights were very low from the beginning of the year showing that either spawning had not taken place in males of this size in the summer of 1950/51 or that it had taken place previously. There certainly was a tendency for gonad weights to rise and perhaps some fish reached the spawning stage but the majority apparently showed a slight increase in gonad size which later declined. The rise in gonad weight of these groups during the later part of the year from July onwards to reach a maximum in December was doubtless indicative of spawning.

From 19·0 cm upwards two periods of increased gonad weight due to spawning activity were evident. The first showed a pronounced maximum in January and a sharp decline to a minimum in May. The second maximum was in December with signs of a sub-maximum in August or September.

Reproductive activity for males in 1951 according to gonad weights was highest in January, then again in August or September and December. Gonads were active from January to March and from July to December. Minimum activity occurred in April, May and June.

(b) Female pilchards.

Fish in length groups 17·5–20·0 cm showed little or no gonad activity between January and July 1951 and it is most unlikely that spawning of these groups had taken place in the first part of the year. A marked increase in gonad weight took place in these groups towards the end of the year. This increase started in July and reached a maximum in December.

From 22·0 cm length upwards two periods of maximum gonad activity were shown by rise in gonad weights. In the length group 20·0–20·4 cm the unusually high weight of 24·4 gm was recorded in February.

Gonad weights were generally high in January and February, on the decline from February to April, lowest in May and began to increase in June or July to reach maxima in August or December.

(iii) 1952 (*see Plates 19–21*).

(a) Male pilchards.

During this year the gonad weight data of fish in the lower length groups 17·5–19·0 cm were more complete than in the previous two years and showed that a very definite increase in gonad weight, suggesting spawning activity, had occurred

in length groups from 18·0 cm upwards in January. After this a decline set in in February and reached its lowest point during April and May for all groups. Weights increased from June again and were highest in November; no data were available in December due to the closed season.

Reproductive activity for males in 1952 was highest in January and February, then again from August to November and probably December. Minimum activity occurred in April and May.

(b) Female pilchards.

Fish in length groups 17·5–18·0 cm showed no activity at the beginning of the year and a slight increase in November, showing that spawning in the previous season either did not occur or was early, and that spawning at the end of the year probably took place.

From 18·0 cm upwards two periods of maximum gonad activity were shown by high gonad weights recorded in January and February and then later in the year from August to December. From January gonad weights declined and were lowest in May, began to increase in June and then increased to a maximum in December.

(iv) 1953 (see *Plates* 22–24).

(a) Male pilchards.

In length group 18·0–18·4 cm gonad weights were low with slight tendencies to increase in June and December. It appears unlikely that spawning occurred in these fish in spite of the previous year's recordings of fairly high gonad weights in the smaller sized males.

From 18·5 cm length upwards, however, two periods of high gonad weight during the year were recorded. The first began in January and declined to a minimum in April or May and then began to increase to reach a maximum again in October or December.

(b) Female pilchards.

Females in length group 18·0–18·4 cm showed very little increase in gonad weight during the year and it is unlikely that this group spawned. The next group 18·5–18·9 cm appeared not to have spawned during the previous season, but their gonad weights increased from June and reached a maximum in September.

From 19·0 cm upwards, however, two periods of maximum gonad activity were shown by high gonad weights recorded in January and February and from June to December. Minimum weights occurred in April and May. High gonad weights were recorded for length group 24·5–24·9 cm in June.

(v) 1954 (see *Plates* 25–27).

(a) Male pilchards.

For males between 17·5–18·5 cm no data were available during the early part of the year. Increase in gonad weight did, however, occur in August, September and October.

From 18·5 cm upwards, two periods of high gonad weight occurred. One was during January and February and the other mainly in August but through to December. In the higher length groups from 20 cm upwards, an early increase in weight of gonads was recorded giving a peak of gonad activity in July or August and a second peak in November.

(b) Female pilchards.

In length groups 17·5–19·5 cm little or no gonad activity in the early part of the year was shown, but from July onwards gonad weights increased. These groups therefore probably did not spawn until the latter part of 1954.

From 20 cm upwards two main periods of high gonad activity were shown. The first began in January, continued in February and declined to a minimum in April and May. Then in June gonad weight increased again to form a small peak in July or August and a higher peak in November as shown by gonad weight.

(vi) Summary of Gonad Weight Data.

The following is a summary of the mean changes of gonad weights of all length groups of male and female pilchards in relation to season.

1. 1950—

Autumn..	March—gonad weights fairly high. April—gonad weights decreasing rapidly. May—gonad weights low.
Winter...	June—gonad weights increasing. July—gonad weights increasing. August—gonad weights increasing.
Spring...	September—gonad weights high. October—slight decrease in gonad weights. November—gonad weights increasing again.

2. 1951—

Summer.. December, 1950—gonad weights high.
January—gonad weights at maximum.
February—gonad weights decreasing.

Autumn.. March—gonad weights still high but decreasing.
April—gonad weights decreasing rapidly.
May—gonad weights low.

Winter... June—gonad weights low.
July—gonad weights increasing rapidly.
August—gonad weights increasing rapidly.

Spring... September—gonad weights high.
October—no data.
November—gonad weights increasing.

3. 1952—

Summer.. December, 1951—gonad weights at maximum.
January—gonad weights at maximum.
February—gonad weights high but decreasing.

Autumn.. March—gonad weights decreasing rapidly.
April—gonad weights low.
May—gonad weights lowest.

Winter... June—gonad weights low, but beginning to increase.
July—gonad weights increasing rapidly.
August—gonad weights high.

Spring... September—data unreliable.
October—data unreliable.
November—gonad weights highest.

4. 1953—

Summer.. December, 1952—no data.
January—gonad weights high.
February—gonad weights higher than January.

Autumn.. March—gonad weights decreasing rapidly.
April—gonad weights lowest.
May—gonad weights lowest.

Winter... June—gonad weights increasing.
July—gonad weights increasing rapidly.
August—gonad weights increasing.

Spring... September—gonad weights decreased slightly
October—gonad weights increasing.
November—data unreliable.

5. 1954—

Summer.. December, 1953—False Bay only; gonad weights fairly high.
January—gonad weights highest.
February—gonad weights highest.

Autumn.. March—gonad weights decreasing.
April—gonad weights low.
May—gonad weights lowest.

Winter... June—gonad weights low, beginning to increase.
July—gonad weights fairly high.
August—gonad weights decreasing.

Spring... September—gonad weights low.
October—gonad weights rising rapidly.
November—gonad weights high.

Summer.. December—False Bay, gonad weights fairly high.

(vii) Gonad Weights in Relation to Sexual Maturity.

Mean gonad weights for male and female pilchards were extracted for length groups in relation to different stages of sexual maturity (see Section 6). Four stages of maturity were used and are tabulated below together with their length groups. The mean gonad weights were extracted for the years 1950 to 1954 during the period of the *total extent* of reproductive activity (see Page 24). These weights may be seen in Table 22, and have been represented graphically in Plate 28. Mean gonad weights per length group for all fish may be seen in Plates 14–27.

Stage.	Standard Length.	
	Males.	Females.
	cm.	cm.
1. Immature.....	18 and under	18·5 and under
2. 50 per cent mature...	18·5 – 19·9	19·0 – 19·9
3. Small mature.....	20·0 – 21·9	20·0 – 21·9
4. Large mature.....	22 and over	22 and over.

For immature male pilchards (stage 1), gonad weights increased from August through to a peak in December and then declined sharply to January and gradually through to March. The gonads of stage 2 males increased from June through to a maximum in December and then declined to March. Stage 3 male gonads increased in weight from June to a suggestion of a peak in November, continued to increase in weight to a second (main) peak in January and then declined gradually at first and then sharply from February to March. Stage 4 male gonads increased from June through to a pronounced sub-maximum in November, fell sharply in December, rose again to a maximum in January and then declined steadily through to March.

For immature female pilchards (stage 1), gonad weights increased from July through to November, rose sharply to a peak in December and declined equally sharply to January and then gradually through to March. Stage 2 female gonads decreased in weight from June to August, increased in September, decreased again very slightly in October and then increased to November, remained the same for December and then began a decline through to March. Stage 3 female gonad weights decreased slightly from June to July, increased steadily to a minor peak in November, decreased slightly to December and then increased to a maximum in February, thereupon falling sharply to March. The gonads of large mature females (stage 4) decreased slightly from June to July and then increased steadily to a maximum in February after which they decreased sharply to March.

From the aforegoing, it appears that *immature pilchards of both sexes undergo certain seasonal physiological changes which cause an increase in gonad weight during the spawning season which is similar to that which occurs in the gonads of mature fish* (see Page 19).

The increase of the gonad weight of stage 2 male pilchards to a maximum in December is the same as that for immature male fish, but is not so pronounced for female stage 2 fish as the curve is much flatter.

The general trend of change in gonad weight for stage 3 and 4 male pilchards is similar except that there is one maximum for stage 3 males and two maxima for stage 4 males. Bearing in mind the fact that the data were obtained over a period of five years, the two peaks for stage 4 males cannot be entirely disregarded, and may therefore indicate that large male pilchards spawn twice in a season. At the same time the possibility of an influx of male fish at this time of the year cannot be neglected.

The gonad weights of stage 4 females increased steadily to a maximum in February while in stage 3 females a submaximum occurred in November followed by a slight falling off and then an increase to a maximum in February. It is interesting to note that stage 3 females reached a maximum gonad weight in February while stage 3 males reached their maximum gonad weight in January. Similarly stage 4 females reached a maximum in February and stage 4 males in January. This showed that the gonads of mature males were generally more advanced in their development than the females.

In general, it is evident that *pilchards spawn once in a season only, but for large males it is likely that more than one spawning per fish per season takes place. Male pilchards reach maximum gonad weight before females.*

In the graphs of gonad weights of female pilchards in relation to sexual maturity (see Plate 28, Fig. 2) it was noticed that the peaks of gonad weight of the larger fish tended to occur later in the year. In order to clarify this, reference to the graphs of gonad weights per length group for the period 1950–54 (see Plates 14–27) was made and the months in which peaks of gonad weight occurred in each of the four maturity groups extracted (see Table 22*a*). These were then plotted graphically (see Plate 28, Fig. 3).

It is seen that a very definite succession of maxima occurred in stage 2, 3 *and* 4 *fish. Maximum gonad weight and therefore spawning occurred in stage* 2 *females in November, stage* 3 *females in January and stage* 4 *fish in February.*

It may be said therefore that small pilchards spawn first i.e. early in the season, and the larger fish later.

It was not considered necessary to deal with male pilchards on the same basis as their spawning activities would presumably coincide with those of the females.

(viii) Reproduction as Shown by Gonad Weight.

From the above data on gonad weights (see Section vi) the spawning seasons were as follows:—

Year.	Total Extent.	Maximum Activity.
1950–51....	August–March.....	September–January.
1951–52....	July–February.....	August–February.
1952–53....	July–February.....	August–February.
1953–54....	June–March.....	July–February.
1954.....	Began in July.....	November–.

Although these periods vary from eight to nine months in extent i.e. up to three quarters of the year, they represent the times during which spawning may have occurred. It will be noted that these periods agree fairly closely with those established by the gross examination and assessment of gonads (see Page 17). Within each period is a shorter period during which intensive spawning activity occurs and on either side of this is spawning which occurs incidentally to the general *making* and decline of gonads before and after the period of maximum spawning. These periods for each year are shown under the heading of maximum activity and for the whole period it may be said *that mean maximum spawning activity according to gonad weights occurs between August and February.*

These data showed that sexual maturity occurred in male pilchards from a standard length of approximately 18 cm and in female pilchards from 20 cm, which gives further confirmation of the findings of the previous section (see Page 20).

The presence of two peaks of gonad weight at certain times during the periods of main gonad activity may indicate that pilchards spawn twice in a season but average trends for various size groups (see Plate 28) over five years tend to confirm this for large males only.

The mean gonad weights of male and female pilchards within lengths 21·0–24·5 cm were plotted month by month for each of the five years 1950–54 (see Plate 29). From these graphs it seems that there are *two maxima in reproductive activity, an early sub-maximum occurring in August or September (and even in July during* 1954), *and a later much greater maximum occurring mainly in December and January, but sometimes as early as November or as late as February. These sub-maxima probably indicate the presence in the commercial catches of pilchards very close to spawning. The fish then depart for the spawning grounds and leave behind fish in a less advanced state of gonad development which gives the impression of a general slackening in gonad activity. These fish in their turn, however, develop rapidly to near spawning condition and depart in the same way, showing a major peak in gonad activity and a rather sudden falling off.*

It may also be seen from these weight data that *during most months of the year the male gonads of each length group weighed more than those of the females.* This is probably due to the fact that the males were ready for reproduction well in advance of females.

Gonad activity is at a minimum during the months of April, May and June and it is during these months that the best catches of pilchards are made in the St. Helena Bay area.

8. Ova Diameters.

(1) General.

Reference to the measurement of pilchard ova diameters has been made previously (Davies, 1954). The method of collection, preservation and measurement of ova has been described earlier, and a table of ova diameters for the year March 1950–February 1951 is included in this paper (Table 23).

The development of all the ova in the gonads of the South African pilchard is not simultaneous and generally development of ova in the posterior region of the ovary appears to be in advance of the rest of the gonad. In some females development of ova appeared to be in three phases with large ova in the posterior region, less developed ova in the centre and the smallest ova in the anterior region. In general, however, it was found that these zones of different development tended to disappear as the ovary came nearer to a state of maximum development before spawning. In certain fish only two thirds of the ovary or less appeared to reach full development with ripe ova present, but the majority of females, when at stages 4 and 5, possessed ovaries which were more than three quarters and often completely full of ripe or nearly ripe ova. Sometimes a small area of ovary situated in the anterior region contained ova in a retarded state of development which were apparently not extruded during spawning and remained behind. In recently spen t fish these undeveloped ova were seen to have been left behind together with small numbers of ripe ova . It is likely that both these types of ova become resorbed. Large numbers of small ova of approximate diameter 2 mm were present in between the well developed and ripe ova of stage 4, 5 and 6 gonads. These apparently did not develop at any stage and were presumably released togethe r with ripe ova during spawning.

(2) Spawning as shown by Ova Diameters.

Although no selection of female fish for ova diameter measurement was intended, it seems

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likely that some selection of females with advanced gonads took place. Because of this, information obtained from these results has been used only in conjunction with other data.

There is, however, a very definite general trend in gonad activity which is shown by the change in diameters of ova. In the autumn months diameters were comparatively low and a slight decrease occurred from March to April. During the winter months diameters remained low but showed an increase in August. In September and October a slight decrease occurred, but was probably of no significance as ova from only one fish were obtained and from November onwards ova diameters increased. In the summer months ova diameters were high, and the largest diameters were recorded in February. Ripe (preserved) ova before spawning had a mean diameter of 1·17 mm (Davies, 1954) so that the ova diameter measurements obtained in February were those from the gonads of fish just about to spawn. *During this year therefore gonads were intensely active in December and January and spawning occurred in February.* This period falls within the already established period of intensive spawning activity for this year according to gonad assessment and weight, viz. September to February.

9. Number of Ova per Female.

Unfortunately no female pilchard gonads at stage 6 were retained for ova counts, but it was found possible to count the ova of stage 4 females, and to estimate the total number of ova per gonad.

The procedure followed was similar to that described by Clark (1934). The gonads were carefully removed and placed in 10 per cent formalin in which they were allowed to harden for five days. They were then taken out of the formalin, carefully dried with filter paper and then weighed to the nearest milligram. A small section of the gonad was then cut off and accurately weighed, after which a count of the ova in this section was made. In order to find out whether the ova of stage 4 gonads were evenly dispersed throughout the ovary, sections were cut from the anterior, central and posterior regions of the ovary, weighed and the ova counted. The differences in the total counts obtained were so small that it was concluded that the dispersal of ova was even. From the count the estimated number of ova in the whole gonad was calculated.

Standard Length.	Number of Small Ova.	Number of Large Ova.	Total.	Remarks.
cm				
22·7	52,365	45,122	97,487	Early Stage 4, gonad weight 14·5 gm.
23·3	6,606	88,444	95,050	Stage 4, gonad weight 16·2 gm.
23·6	8,067	99,937	108,004	Stage 4, gonad weight 17·4 gm.
24·6	12,443	97,945	110,388	Stage 4, gonad weight 19·4 gm.

It was found that most ova were large and well developed and smaller numbers were less developed. The large ova in a preserved state were opaque and showed a range of variation in diameter of approximately 0·7–1·4 mm, while the medium sized ova were semi-opaque and had a diameter range of approximately 0·4–0·6 mm. Small transparent ova of diameter $\pm$ 0·2 mm were present in all parts of the ovary. These were not counted.

From the counts in the table above it is seen that for these female pilchards at stage 4 there appeared to be two definite categories of ova, a majority of large ones and a much smaller number of medium sized ova. The medium sized ova were distributed throughout the ovary but were more concentrated in the anterior region of the ovary. A stage 4 gonad is, however, some distance from spawning and it is probable that the majority of the medium sized ova catch up in their development in time for spawning. Although the possibility cannot be discounted that there are two spawnings per season, a large first spawning and a smaller secondary spawning, the examination of stage 6 and 7 gonads does not support this, since gonads at stage 6 contain nearly all ripe ova and at stage 7 are always almost devoid of eggs.

It is interesting to note that *the total count of ova for a fish of standard length* 23·3 *cm was* 95,050 which is close to the ova count for a 23·1 cm California sardine of 104,340 (Clark, 1934).

From the counts obtained *it appears that the numbers of ova increase with the size of the fish. It* is therefore difficult to give an estimate of the average number of ova spawned per female per

season. *This number is estimated to be roughly* 95,000 *ova.*

10. Pilchard Ova in the Plankton.

The method of collection of ova and the area of search for pilchard eggs have been described earlier in this paper. The question of the location and distribution of pilchard ova in relation to main spawning areas etc. will be dealt with in detail in a separate investigational report.

The following is a brief account of the numbers of ova obtained and their relationship to the spawning of the pilchard.

(i) Routine Offshore Stations.

(a) 1950 (see *Plate* 30, *Fig.* 1).

During this year pilchard ova were obtained in small numbers from September through to December, showing that spawning on a small scale took place during spring and summer.

(b) 1951 (see *Plate* 30, *Fig.* 2).

The spawning which started in the spring of 1950, did not apparently continue beyond December in the offshore routine area as no ova were collected until August. Spawning on a more intensive scale than in the previous year took place from August to November, with September and October peak months. No ova were recorded in December.

(c) 1952 (see *Plate* 30, *Fig.* 3).

Ova were again collected in January and February showing that spawning probably took place from August 1951 to February, 1952, i.e. mainly in the spring and summer. Ova were again found from September to December with highest numbers in October and November.

(d) 1953 (see *Plate* 30, *Fig.* 4).

The 1952 spawning continued through January to March, 1953. Ova were again found from June to December with maximum numbers in July and September.

(e) 1954 (see *Plate* 30, *Fig.* 5).

The 1953 spawning continued through January, February and March and large numbers of eggs were obtained. Ova were again found in May and June and then from August through to December. The highest number of ova was recorded in September but large numbers were also recorded in August and November.

(ii) Routine Inshore Stations.

(a) 1950 (see *Plate* 31, *Fig.* 1).

Pilchard ova were obtained from August through to December with highest numbers in September and October. From the collection of ova in the area of offshore and inshore stations it appears that during 1950 more spawning occurred in St. Helena Bay area than in the offshore area.

(b) 1951 (see *Plate* 31, *Fig.* 2).

Spawning continued from December, 1950 through to February, 1951 and ova were obtained at the inshore stations in small numbers during every month of the year except March and August when no stations were worked. This occurrence of ova during the year 1951 was unusual. The peak months were February and September.

(c) 1952 (see *Plate* 31, *Fig.* 3).

Ova were obtained from January through to April, with the largest number in March, and then in large numbers from September to November, with October the peak month.

(d) 1953 (see *Plate* 31, *Fig.* 4).

Spawning occurred in January and March—no stations were worked in February. Ova were obtained in June, then again from August to October and again in December. In general, ova were obtained sporadically and in small numbers during this year.

(e) 1954 (see *Plate* 31, *Fig.* 5).

No inshore spawning occurred during the first half of the year, but spawning began on a small scale in August, continued through September and ceased altogether in October. Spawning was generally on a very small scale during this year.

(iii) Summary of Spawning Activity.

(a) Routine Offshore Stations (see *Fig.* 2).

1. 1950—
   - Spring... September—light spawning. October—very light spawning. November—5 ova only.
   - Summer.. December—very light spawning.

2. 1951—
   - Winter... August—light spawning.
   - Spring... September—fairly heavy spawning. October—heavy spawning. November—light spawning.

3. 1952—
   - Summer.. January—light spawning. February—fairly heavy spawning.
   - Spring... September—fairly heavy spawning. October—fairly heavy spawning. November—fairly heavy spawning.
   - Summer.. December—fairly heavy spawning.

4. 1953—
   - Summer.. January—light spawning. February—fairly heavy spawning.
   - Winter... June—light spawning. July—very heavy spawning. August—heavy spawning.
   - Spring... September—very heavy spawning. October—heavy spawning. November—2 ova only.
   - Summer.. December—fairly heavy spawning.

5. 1954—
   - Summer.. January—very heavy spawning. February—exceptionally heavy spawning.
   - Autumn.. March—very heavy spawning. May—6 ova only.
   - Winter... June—very light spawning. August—very heavy spawning.
   - Spring... September—exceptionally heavy spawning. October—heavy spawning. November—very heavy spawning.
   - Summer.. December—light spawning.

(b) Routine Inshore Stations (see *fig.* 2).

1. 1950—
   - Winter... August—light spawning.
   - Spring... September—fairly heavy spawning. October—fairly heavy spawning. November—9 ova only.
   - Summer.. December—8 ova only.

2. 1951—
   - Summer.. January—very light spawning. February—fairly heavy spawning.
   - Autumn.. April—very light spawning. May—very light spawning.
   - Winter... June—very light spawning. July—9 ova only.
   - Spring... September—light spawning. October—very light spawning. November—very light spawning.
   - Summer.. December—3 ova only.

3. 1952—
   - Summer.. January—3 ova only. February—very light spawning.
   - Autumn.. March—fairly heavy spawning. April—3 ova only.
   - Spring... September—fairly heavy spawning. October—fairly heavy spawning. November—fairly heavy spawning.

4. 1953—
   - Summer.. January—2 ova only.
   - Autumn.. March—very light spawning.
   - Winter... June—very light spawning. August—very light spawning.
   - Spring... September—light spawning. October—light spawning.
   - Summer.. December—2 ova only.

5. 1954—
   - Winter... August—8 ova only.
   - Spring... September—light spawning. October—light spawning.

(iv) Spawning as indicated by Ova in the Plankton.

The extent of the spawning season and the months of main activity for each year as shown by the above data were as follows:—

1950–51.—September – December, main months September and October, main spawning took place in the area of routine inshore stations.

1951–52.—Main spawning August–November, 1951, January–February 1952, main months September and October, 1951 and February, 1952 at offshore routine stations. Light spawning almost throughout the year and through to April, 1952 at inshore routine stations, main month February.

1952–53.—Main spawning September, 1952–March, 1953, main months October and November, 1952 at offshore routine stations. Spawning

at inshore routine stations from September–November, 1952 and in January and March in 1953, main months September and October.

1953–54.—Main spawning June, 1953–March, 1954, main months July, September, 1953 and February, 1954 at routine offshore stations. Light spawning at inshore routine stations in June, August to October and December, 1953; main months September and October.

1954.—Spawning occurred in May and June, but main spawning from August to December, main months September and November, at routine offshore stations. Light spawning at inshore stations from August to October, main month October.

The ova counts reveal in general that although the extent of the spawning season of the pilchard is considerable and *that spawning may in fact be almost continuous during the year there are definite peaks of spawning activity* (see Plate 57). *These peaks are in spring and summer* but they are by no means rigid and *may move in either direction to make an early or late main spawning season.* The peaks of spawning activity, as shown by ova in the plankton, may occur as early as July or as late as February. *The usual months of peak spawning activity were, however, found to be September, October and February.*

Although *spawning of considerable importance may take place in St. Helena Bay, as in September and October,* 1950, *most spawning usually takes place in the area of offshore routine stations as in the years* 1951–54.

It is of interest to compare the numbers of ova collected in the plankton for each year of the period 1950–54 (see Table 46). The year 1950 is not comparable with the other years as data at sea were only collected from April onwards. From 1951 onwards, however, the total number of ova increased each year from 12,724 in 1951 to 92,790 in 1954.

This suggests that either each of the four years was a better spawning year than the previous one or that the areas in which the stations were worked were used progressively more for spawning. It is perhaps significant that more upwelling occurred in the spawning area in 1954 than in previous years. These possibilities will be discussed in a later paper

11. Condition Factor.

(i) The Relationship between the Weight and the Length of the pilchard.

Before any consideration of a weight-length or condition factor can be given, the relationship between the weight and the length of the pilchard must be ascertained. For fishes in general the weight, which is a measure of volume, is said to vary approximately as the cube of the length and in order to find this relationship for the pilchard, weight-length curves were constructed (see Plates 32, 33). As there was a possibility that differences might be found for males and females, the sexes were treated separately. The two weight-length curves showed that with increase in length there is a greatly accelerated increase in weight and that the weight varies approximately as the cube of the length.

From these curves the general relationship of weight to length of male and female pilchards is seen to be almost identical. The curves show the absolute change in weight between lengths, and not the relative change in weight; since, for example, a variation of 20 gm in weight at 13 cm length is far more significant than the same variation in weight at say 26 cm length, it is necessary to express the weight-length relationship in some other form.

The usual form in which the weight-length relationship for fishes is written is $w = Kl^3$, where w = weight, l = length and K a factor which varies for different species, but varies for a single species only as the weight fluctuates in relation to the cube of the length. The factor K is therefore an index of the relationship of weight to length and is known as the Condition Factor. Condition factor $K = \frac{w}{l^3}$ but in order to eliminate decimals and for convenience it is used in the form $K = \frac{100w}{l^3}$.

The material used for the study on the weight-length relationship of the pilchard consisted of all the fish examined in the course of the normal sampling of the commercial catches during the calendar year 1952. Altogether 3,558 male and 4,467 female pilchards were examined (see Tables 24, 25) making a total of 8,025 fish.

From the tables it is seen that for the smaller length groups (12–18 cm standard length) small numbers of fish were obtained (74 males and 74

females) and the majority of fish were in length groups 18–24 cm for males, and 18–25 cm for females. This is reflected in the scattering of points at lengths below 18 cm and above 24 cm for males and above 25 cm for females in the weight-length curves (see Plates 32, 33).

Statistical treatment of data.

The weight-length factors were derived, as already stated, from the formula $K = \frac{100w}{l^x}$ where K is the factor, w the weight of the fish, l the length and x the index or power to which l must be raised in order to express the relationship between the weight and the length.

The weight-length curves (Plates 32, 33) were fitted to the data (Tables 24, 25) by the method of least squares using the formula $Kl^x = w$ for males and females separately from which the values of K and x were found, i.e.

$$x \log l + \log K = \log w$$

$$(\log l)^2 x + (\log l)(\log K) = (\log l)(\log w)$$

Let b = number of fish, $a = b(\log l)$, x = index, y = factor, $n = b(\log w)$, then the normal equations take the following form:—

$$(\Sigma a^2)x + (\Sigma ab)y = \Sigma (an)$$

$$(\Sigma ab)x + (\Sigma b^2)y = \Sigma (bn)$$

The logarithms of the length and weight of male and female pilchards were also plotted (see Plate 35) and the straight line fitted as described later.

In order to find the error in the condition factor calculated on the assumption that the weight of the pilchard varies as the cube of its length, the year's data on the weight and length of male and female pilchards were subjected to a detailed analysis. The average weight at each millimetre of length was determined and from these data the values of K and x in the equation $w = Kl^x$ were calculated by the method of least squares as described above.

Mathematical Relationship between Weight and Length.

The value of x for male pilchards was found to be 2·928 and K = 0·01686 while for female pilchards the value of x was 2·808 and K = 0·02451. In both cases the value of x was less than 3 so that the weight of pilchards varies not as the cube of their length but as $l^{2\cdot928}$ for males and $l^{2\cdot808}$ for females. The difference between these values may be largely due to the fact that the length range of males (12·4–24·9 cm) differed from that of females (10·9–25·9 cm) and also that a different arithmetical result would naturally be derived from the two sets of data for the male and female fish.

The curves were fitted to the weight-length data (see Plates 32, 33) for males by calculation of the weight at each centimetre of length when $x = 2\cdot928$ and K = 0·01686 and for females when $x = 2\cdot808$ and K = 0·02451 by means of the formula $w = Kl^x$. From these graphs it is seen that the weight-length curves do not fit the data throughout their length, and that the curves for male and female pilchards are almost identical. The close agreement of the variation of weight with length of males and females is clearly seen in the graph for both sexes (see Plate 34). In the lower length groups between 11–17 cm the weight increased at a rate less than either $l^{2\cdot928}$ or $l^{2\cdot808}$. Between 17–18 cm there was some dispersal of weights above and below the curve for female and above only for male pilchards. From 18–23 cm the weight increased almost exactly with the curve and beyond 23 cm length some scattering of the weights occurred probably due to the small numbers of fish sampled, but the average increase in weight appeared to be very close to the curve.

As the relationship between the weight and the length of both male and female pilchards appeared to be less than the calculated powers of 2·928 and 2·808 respectively for lengths below 18 cm, the logarithms of the weights were plotted against the logarithms of the lengths in order to determine whether the weight-length relationship was a straight line for all lengths (see Plate 35). The straight line was fitted by means of the formula $y = mx + b$, where y represents any point on the ordinate, x any point on the abscissa, m the slope of the line and b the distance from the zero origin to the point where the straight line cuts the vertical axis. Calculations for the fitting of the straight line were made for males where $m = 2\cdot928$ and $b = \bar{2}\cdot2269$ (the log of 0·01686) and for females where $m = 2\cdot808$ and $b = \bar{2}\cdot3894$ (the log of 0·02451). It was found, however, that the points for males and females were in most cases the same and at the most differed by 0·02. It was therefore decided to plot the logarithms of the weights and lengths of males and females together and to fit a

single straight line for both sexes (see Plate 35). It is seen that the straight line fits the data fairly well, but for small fish less than ± 16 cm long the length increases more rapidly than the weight. From 17–18 cm the weight increases at a higher rate and for the remaining lengths the increase coincides more closely with the straight line. It must be emphasised that the departures from the straight line are small, but they probably account for the fact that the mean condition factor for pilchards below 15·5 cm in length is lower than for the other length groups (see Plate 43).

It may be said therefore that, based on data for male and female fish taken during all seasons over a period of a year and involving the examination of 8,025 *fish, the weight of the pilchard increases at a rate slightly less than the cube of its length, viz. to the power of* 2·928 *for males and* 2·808 *for females. For males and females below* ± 16 *cm in length the increase in weight is at a slightly lower rate, between* 17–18 *cm at a slightly higher rate and for the remaining sizes approximately at the same rates as those stated above. For purposes of the study of the weight-length or condition factor of the pilchard the formula should be* $K = \frac{100w}{l^{2.928}}$ *for males and* $K = \frac{100w}{l^{2.808}}$ *for females, but the formula* $K = \frac{100w}{l^3}$ *is considered to be sufficiently accurate for general use.*

Comparison of K and x with that of the California Sardine.

It is of interest to compare the values of weight-lenght factor K and the length indices x for male and female pilchards for the South African pilchard and the California sardine (*Sardinops caerulea*).

The values of K and x for male and female California sardines were obtained from data collected during the six months from May to October (Clark, 1934). These values were calculated and curves fitted by the method of least squares using weight data in grams and length data in millimetres. As the S.A. pilchard length data were in centimetres the values of K for the two species were not comparable. The values of K for the South African pilchard were therefore recalculated for comparison with those of the California sardine by means of the formula $Kmm = Kcm \times \frac{1}{10}x$.

For male fish, the value of x for the California sardine was found to be 2·843, while x for the pilchard was 2·928. The difference between these two figures is remarkably small. For female fish, x for the sardine was 2·777 and for the South African pilchard 2·808, showing a difference of 0·031.

For male fish the value of K for the California sardine was found to be 0·0000289, while K for the pilchard was 0·00001990. For female fish, K for the sardine was 0·0000408 and for the South African pilchard 0·00003815. The values of these weight-length factors are very close.

The above data on the California sardine were collected over a period of six months and therefore did not allow for full seasonal variation. Further data on the California sardine (Clark, 1934) showed the weight-length curve for female sardines calculated over a period of a year. In this case x was found to be 2·9353 and K = 0·0000175. The relation between weight and length for male and female sardines was stated to be the same. The comparison between the South African pilchard and the California sardine should therefore be more valid on the basis of the latter figures for the sardine and the figures for female pilchards.

On this basis, x for the California sardine was 2·9353 and for the South African pilchard 2·808 while K for the sardine was 0·0000175 and for the pilchard 0·0000382. The difference in the weight-length curves is shown in the graphs (see Plate 36). It is seen that, while the curves are similar in form, *the weight of the California sardine in relation to its length is consistently lower than for the South African pilchard by an average amount of over* 9 *gm or* 10 *per cent.* At the lower length groups this amount is more than 10 per cent but with increasing length the difference becomes less, e.g. approximately 8 per cent at 25 cm. It is not known whether this difference would be confirmed by a comparison of Californian and South African fish on exactly the same basis and with larger numbers of fish, or during different years.

(ii) Mean K for all Fish 1950–54.

During the standard sampling procedure for pilchards at the field stations, the condition factor

K was calculated for all fish. The results of these calculations in the form of mean K for all fish per month were plotted graphically for each of the five years (see Plate 37, Figs. 1–6).

It was found that throughout the period, K *for male and female pilchards coincided almost exactly.* Wide deviations of K between males and females occurred only when very few fish were obtained, as for example in September, 1952.

In general, K showed the same pattern of seasonal variation in each year. *Condition factor was high in the summer months of December, January and February and continued to increase in most years to reach a maximum in March, the first month of autumn. From March onwards condition factor declined sharply through the autumn and winter months to reach a minimum in August or September. From September through spring and summer K increased, rapidly at first and then probably steadily each month.* Low values of K such as those obtained in November, 1953 were due to the fact that only small numbers (35) of small sized fish were examined.

Although the values of condition factor varied for each month of the five years, the fluctuations were, in general, the same. In 1950 and 1952, larger numbers of fish below ± 20 cm, were represented in the commercial catches (see Plate 56) yet the general fluctuations of K for these years was the same as for 1951, 1953 and 1954.

As the size composition of the commercial catches consisted mainly of fish of over 20 cm length, mean condition factor for *all* fish gave a good indication of the average weight-length relationship of the fish comprising the commercial catches. For the period 1950–54 mean K for all fish is therefore considered to be a good index of condition of the pilchards caught commercially during this period (see Plate 37, Fig. 6).

(iii) Mean K for Length Groups 21·5–24·5 cm.

Having established that pilchards are sexually mature at approximately 21·5 cm standard length, it was decided to consider the condition factors of fish in length groups 21·5–24·5 cm. These groups should during the course of a year contain the highest numbers of sexually active fish and at the same time form the bulk of the commercial catches. In view of this fact immature fish would be excluded and any modifying effect on K caused by smaller fish would be eliminated.

Condition factor for the 21·5–24·5 cm length groups (see Plate 39) showed exactly the same fluctuations for each month during the year as K for all fish (see Plate 38), and values were very little different from K for all fish.

It appears, therefore, that for purposes of assessing the seasonal fluctuations of the condition factor of the pilchards caught in the commercial catches the mean value of K for all fish is adequate, provided that the proportions of the various length groups represented remains approximately the same as those of 1953.

During the period 1950–54, the length composition of the commercial catches did not vary to any great degree (see Plate 56) for purposes of comparison of condition factor. Variation which would have the most effect on K would be the presence of unusually large numbers of fish below ± 20 cm length. From this point of view the years 1951, 1953 and 1954 were the same, but in 1950 and 1952 the commercial catches contained larger numbers of fish smaller than 20 cm, nevertheless K for all fish and for length groups 21·5–24·5 cm was almost identical.

(iv) Mean K for Length Group 18·0–18·4 cm.

The mean condition factor for all fish in the length group 18·0–18·4 cm was plotted for the period 1950 to 1953. There were too few fish in this group during 1954 (see Plate 40, Figs. 1–4). The above length group was chosen as being the lowest one which was fairly well represented in the commercial catches.

Although there is greater variation of K for this group, the general fluctuations are very much the same as for the condition factor for all fish (see Plate 37, Figs. 1–6). It would appear, therefore, that the inclusion of fish of these lower length groups for purposes of the calculation of K for all fish as a general index of the condition of the commercial catches does not upset the trend of the final graphs.

(v) The Relationship between K and Length.

As the condition factor of a fish depends on the relationship between its weight and its length, it is important to know the variations of this relationship with such factors as growth and reproductive

activity. Increase in age and size is accompanied by sexual maturity, enlargement of gonads and a seasonal increase in weight. It would therefore be expected that during the spawning season the condition factor of sexually mature fish would be relatively much greater than that of immature fish.

In order to find out the change in condition factor with the length of the pilchard, the mean condition factor per half centimetre length group per month was extracted for male and female fish separately for the two years 1952 and 1953 (see Tables 26, 28, 30 and Plates 41–43). These two years were chosen because large numbers of fish were obtained during the period and because the greatest range in length was obtained.

During 1952 (see Plate 41) condition factor for males and females below 18 cm standard length was generally low but very erratic. Fish below this length are not sexually mature and this may account for the fact that K was lower than that of larger fish. The erratic rise and fall of condition factor between 12 cm and 18 cm was probably due to the fact that the numbers of fish obtained in these length groups were very small (148) in comparison with those for the remaining larger length groups (7824). In most months length groups below 18 cm were very poorly represented (see Tables 26, 28). From ± 17–18 cm the condition factor increased steeply and then remained steady up to ± 22 cm from where a gentle decrease occurred down to the largest fish of length ± 26 cm.

In 1953 condition factors for male and female pilchards were generally similar for all length groups and the smaller length groups under 18 cm showed far greater agreement (see Plate 42). This was almost certainly a reflection of the fact that a relatively larger number (249) of fish in the smaller length groups as opposed to 4,256 in the remaining larger groups was examined.

Up to ± 18 cm condition factor was steadily low, much lower than for 1952, but at 18 cm a sharp increase occurred. This rise in K continued up to 20·5 cm, after which a steady decrease took place down to the largest fish of ± 26 cm.

As the variations of condition factor for male and female fish were small, and their general fluctuations the same, they were combined for 1952 and 1953 and further combined into a single series of means for the two years (see Table 30 and Plate 43).

It is seen that *condition factor for all fish below a length of* ± 17 *cm is low. From* ± 17 *cm to* ± 20·5 *cm a steady increase in K occurs and from* ± 20·5 *cm to the largest fish a steady decrease in condition factor takes place.*

It is considered that *the generally low condition factor found in fish below* 17 *cm in length is related to the fact that these fish have not reached sexual maturity. The sharp rise in the condition factor of pilchards larger than* 17 *cm and extending to* 20·5 *cm. is almost certainly bound up with the onset of sexual maturity from* ± 18 *cm onwards.*

The decline in condition factor from ± 20·5 cm upwards is not easy to explain in terms of sexual maturity, particularly as all fish are mature at 22 cm. It may, however, be connected with some physiological change or a general decline associated with senility.

Since the change in average condition factor in relation to length appears to be largely related to sexual maturity, it is important to examine this relationship further.

(vi) The Relationship between K and Maturity Stages.

Condition factor for male and female pilchards for certain length groups based on stages of maturity was calculated for 1952 and 1953 (see Tables 27, 29). The stages of maturity were as follows: (1) immatures, (2) ± 50 percent matures, (3) small matures and (4) large matures. The size ranges of these categories for male and female pilchards may be seen in Tables 27, 29 and Plates 44, Figs. 1, 2 and Plate 45 Figs. 1, 2.

In 1952 the condition factor of immature fish (stage 1) was generally lower than that of all larger fish for male and female pilchards, but underwent rather extreme fluctuations. Condition factor was high in January and declined rather erratically to May. For males K increased from June to November but for females rose in June, dropped again steeply in July and August and rose steeply in November. Condition factor for immature males and females in 1952 was high in

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January and February but decreased in these months through to May and was followed by an increase through to November.

The condition factor of the larger groups including the ± 50 per cent matures (stage 2), small matures (stage 3) and large matures (stage 4) underwent similar fluctuations during 1952 for both male and female pilchards. It was high in January, decreased in February and March, rose slightly in April, decreased in May, June and July, and then rose steeply from August through to November. The condition factor of no single group appeared to remain consistently higher or lower than any other group during the year.

The erratic changes in the condition factor of the immatures are without doubt due to the small numbers of fish of these smaller length groups encountered in the commercial catches. The larger groups (2–4) were far better represented.

The year 1953 may be looked upon as a continuation of 1952 for the larger groups 2, 3 and 4. Condition factor for males and females continued to rise through January, February and March and then declined through to September when a sharp increase occurred up to October which levelled and became a slight decline through to December.

For immatures (stage 1), no data were available during January, February and March 1953. Condition factor was, however, comparatively high in April for males and females of this group but declined through to May (males) and June (females). After this there was a slight rise to July, a decrease through to November and an increase from November to December.

In general, therefore, *the condition factor of mature male and female pilchards belonging to groups* 2, 3 *and* 4 *was high during the months of the spawning season from September to February or March and low during the non-spawning months May to August.*

The erratic fluctuations of immature males and females of group 1 tended to mask the general seasonal trend of condition factor for this group particularly in 1952. This was no doubt due to the relatively small numbers of these length groups encountered in the commercial catches. It seems more than likely, however, that *the general fluctuations of condition factor for immature fish of the length groups obtained, follows the same seasonal pattern of variation as that of the larger mature groups, although the condition factor of the former remains consistently lower.* This was more noticeable in 1953.

The similarity of the seasonal fluctuations of the condition factor of both immature and mature pilchards may further indicate the presence of an innate physiological rhythm of reproduction in the immature fish (*see Pages* 19 *and* 24).

(vii) Comparison of K, K_1 and K_2 for 1953.

It was suspected that condition factor might be affected by the presence of food in the alimentary system and by the size of the gonads. In order to test this two other condition factors were calculated for all fish for one year (1953). The quantity of plankton eaten and the variation in state of gonads would affect the total weight of the fish, which would affect the condition factor. While the actual values of these condition factors would doubtless change, it was much more important to ascertain what effect, if any, these changes might have on the general trend and seasonal fluctuations of condition factor in general.

The condition factors calculated in 1953 were K, K_1 and K_2, where:—

(*a*) $K = \frac{100w}{l^3}$ where w = total weight of fish. l = total length of fish.

(*b*) $K_1 = \frac{100w_1}{l^3}$ where w_1 = total weight of fish with entire alimentary system removed. l = total length of fish.

(*c*) $K_2 = \frac{100w_2}{l^3}$ where $w_2 = w_1$ — weight of gonads. l = total length of fish.

In K_1 the effects of heavy feeding or no feeding at all were eliminated and in K_2 no disturbance in weight would be felt by the weight of highly active or inactive gonads.

From the graphs (see Plate 38) it is seen that K_1 was consistently lower than K throughout the year, and K_2 was consistently lower than K_1 throughout the year. *But the fluctuations of K, K_1 and K^2 throughout the year were almost identical.*

It seems, therefore, that *the fluctuations of condition factor during the year are not directly related to either feeding or reproduction and that condition factor (K) for all fish may be used as a true index of condition of the fish.*

It is of interest to note that condition factor values for female pilchards were higher than those of males from January to May, 1953, while from August to November K values for males were higher. Similar tendencies were not, however, recorded during other years.

(viii) Comparison of K with oil yield.

A factor which might affect the condition factor of the pilchard is the amount of fat stored in the body tissues of the fish which is directly related to the oil yield.

Mean oil content of pilchards in gallons per ton of fish obtained from factory returns (see Table 31) were compared with condition factor for the pilchard catches of 1953. Unfortunately, returns for every month of the year were not available due to the absence of fish and the closed season, but the figures obtained are representative of the mean returns from the majority of factories of the West coast of the Union of South Africa.

It is hoped that in the future a detailed comparison of the oil content of the pilchard and its condition factor will be possible, by means of the oil extraction and chemical analysis of the same fish samples from which the condition factor was calculated.

It is seen (Plates 38, 39, Table 31) that the general fluctuations of the oil yield curve are the same as fluctuations of K, K_1 and K_2 and the condition factor for the larger length groups 21·5–24·5 cm with the exception that oil yield continued to increase in April when K had already begun to decline.

It was found to be extremely difficult to obtain oil returns for pilchards during the period 1950–54 due mainly to the fact that catches of pilchards and maasbankers were frequently mixed for purposes of processing and the final returns given in gallons of mixed oil. This made it impossible in many cases to ascertain even an average oil yield for pilchards alone. A further complication lay in the fact that the amount of pilchard offal from the canneries used for oil extraction was often not specified in the factory returns. For these reasons it is stressed that the actual figures for oil returns are not accurate and in some cases are unbelievably high.

During 1950, however, it was possible to obtain a fair set of mean oil returns for the period March to December and comparison of oil yield (see Table 31) with mean K values for all fish shows an almost identical trend (see Plate 46). Oil yield and K drop consistently from March through to August. There is a barely perceptible increase in K in September which remains approximately the same in October while oil yield drops steadily through September to October. In November and December a steep rise in both K and oil yield takes place.

It appears, therefore, that the fluctuations of K throughout the year may correspond with and reflect the rise and fall of the oil yield of the pilchard catches.

(ix) Condition Factor in Relation to Gonad Activity
(see *Plates* 11, 37 *Figs.* 1–6 *and Plate* 47).

The condition factor of fish of all length groups from the commercial catches is high in the summer months December, January and February. Gonad activity is also intensive during summer. During autumn condition factor decreases steadily. Gonad activity decreases rapidly in autumn and by April is very low. Condition factor continues to decrease through the winter months and is usually lowest in August. Gonad activity remains low until July sometimes August, or even September before increased activity occurs. Condition factor begins to rise in September and continues to rise through the spring. Gonad activity increases right through spring.

It appears therefore that condition factor is generally high during periods when gonad activity is high, but that the decline in condition factor which starts in the autumn and continues through to August or September is not in agreement with the period of low gonad activity from April to July.

It is evident that there is some relationship between condition factor and reproductive activity, but this relationship is by no means clear, (see Plate 47). The fluctuations of K for the commercial catches are similar to the fluctuation in the oil yield and hence to the fatness of the pilchards. During the period April to July when gonad activity is lowest, oil yield and condition factor decrease rapidly. This may be explained by the fact that during this period gonads are generally on the make and in consequence cause a physiological drain on the rest of the fish in order to favour the development of the gonads.

(x) General.

In general the variation of the mean condition factor of commercially caught pilchards from the West coast of the Union agrees with that of the California sardine smaller than 20 cm in length. According to Clark (1934) the study of the seasonal changes in weight-length factors indicated that young sardines, smaller than 20 cm, have a minimum of fat in the early winter months November to January. In the South African pilchards comprising the commercial catches, condition factor is low in the corresponding months May to July. It is still falling in these months and is therefore not a minimum. The smaller sizes of Californian fish have a maximum fat content in August, September and October. For the corresponding months of February, March and April in the Union commercially caught pilchards of larger size possess their highest condition factor.

Adult breeding California sardines have a maximum weight in autumn and winter and experience a loss of fat throughout the summer as the spawning season progresses. The South African pilchard's condition factor falls during autumn and winter and increases in summer. The seasonal variation of the condition factors of adult South African and Californian fish is apparently inverse.

It is important to consider whether there is any connection between the condition factor of pilchards and their condition in relation to canning and reduction. At certain times of the year pilchards become soft and watery within a short time after catching. These fish are known locally as *pap* fish and pilchards in this condition are quite unfit for either canning or reduction. Fish caught in the same vicinity may be in perfect condition or completely *pap* and the latter condition may occur during all seasons of the year but is usually at its worst in February, March, August and September. It is perhaps of some significance that these are active spawning months for the pilchard and very often female fish with large ovaries containing considerable quantities of mucus are predominant in *pap* catches. *Condition factor*, on the other hand, is at its highest in February and March and at its lowest in August and September and therefore *has no apparent bearing on the "pap" condition of pilchards.* A more likely explanation for this condition could be the presence of bacterial or protozoal organisms in the tissues such as *Chloromyxum* in snoek (*Thyrsites atun*).

12. Ratio of Sexes in the Commercial Catches.

In the course of routine sampling of the commercial catches of pilchards the ratio of male to female fish was calculated for each month for the period March 1950 to December, 1954 (see Tables 32–38 and Plate 48, Figs. 1, 2). As the proportion of males to females remained generally constant throughout the period, apart from minor fluctuations at times when sampling was particularly poor, the results have been expressed as a ratio of male to female fish averaged for each season during the whole period (see Table 37, Plate 48, Fig. 2).

It may be stated therefore that *the mean ratio of male to female pilchards in the commercial catches of the West coast for all seasons is* 44:56, with a constant predominance of females over males by 12 per cent.

When this ratio is treated in relation to length groups, however, it is found that in length groups 18–19 cm, the ratio of males to females is unsteady, probably due to the fact that comparatively few fish are caught in these groups (see Table 38, Plate 48, Fig. 1). Between lengths 19 cm and 22 cm, however, males predominate and the ratio is 56:44, i.e. the opposite to that of the mean ratio of all fish, but from 22 cm onwards the numbers of female fish increase steeply while the numbers of males decrease just as steeply. *The majority of fish over 22·5 cm in length are therefore females,* and 100 per cent of the catches of fish in the length group 25·5–26 cm are females. From 22·5 cm length upwards the numbers of male pilchards decrease rapidly to reach nil at length group 25·5–26 cm.

According to this analysis of the ratio of sexes in relation to length group which shows an initial preponderance of males and a subsequent preponderance of females from 22 cm onwards, the change must no doubt be ascribed to a difference in the rate of growth of males and females which have passed the juvenile stage. The question of the age and rate of growth of the pilchard will be considered in a later paper.

13. Spawning in Relation to Environmental Factors.

(i) General.

In the pilchard, as in other fishes, there are almost certainly a series of innate physiological changes causing gonad activity to range from complete inactivity through the various stages of development to actual spawning. It is likely, however, that apart from this internal rhythm, some other factor such as a rise in water temperature, or a combination of factors act as a stimulus to the physiological process. Further, spawning is not likely to take place unless conditions are favourable; in other words, for reproduction to take place a suitable environment is essential otherwise reproduction will either be prevented or will be unsuccessful. If suitable conditions are not available then migration takes place in order that they may be found. A knowledge of the factors of the environment which prevent, limit or promote reproduction is therefore of considerable importance. Although other factors may be concerned in the spawning of the pilchard, sea temperature, air temperature, and salinity are considered here.

(ii) Temperature as a stimulus to Gonad Activity. (see *Plate* 49, *Figs.* 1, 2, 3 *Plate* 50 *and Tables* 39–44).

In order to find out the effect of water temperature on gonad activity, the gonad weights of male and female pilchards in the larger length groups 21·0–24·5 cm were plotted in relation to mean temperatures for the 0–50 metre layer and the surface of the sea in St. Helena Bay itself. For this purpose average data from routine offshore stations L, M, N, O and Q were taken as they gave a good coverage of the bay. Air temperature readings taken at these stations were also used.

The changes in weight of gonads for male and female fish during the three years were generally the same and in each case graphs for the two sexes may be regarded as one. During 1950–51 (see Plate 49, Fig. 1) air and surface temperatures were, broadly speaking, on the increase from September through to January. During this period gonad weights increased rapidly. The 0–50 metre temperatures rose in September and October, dropped in November and December but rose again in January. Surface and 0–50 metre temperatures decreased in February and March, but air tempreatures increased slightly. Gonad weights decreased steadily from January to June, and then rose rapidly from June to August. In May temperatures in the 0–50 metre layer and at the surface rose steeply. Air temperatures decreased slightly from June to August.

While there is no doubt that air and surface temperatures are subject to extensive fluctuations in relation to changes in meteorological conditions and that the same applies to 0–50 metre temperatures in relation to water movements such as upwelling, influx of oceanic water and flooding of the Berg River, it appears that these temperatures may have some bearing on reproductive activity in the pilchard.

For example, the rise in air, surface and 0–50 metre temperatures in October 1950 possibly stimulated the rapid rise in gonad weights which followed in November. The falling off of surface and 0–50 metre temperatures in January and February coincided with the completion of spawning and the start of a prolonged decline in gonad weights. The increase in surface and 0–50 metre temperatures in May perhaps stimulated the rise in gonad weights recorded in June.

During 1953 (see Plate 49, Fig. 2) air and surface temperatures ran remarkably close together during the whole year, and 0–50 metre temperatures followed similar trends. High surface and air temperatures in March, and for the 0–50 metre layer in April, coincided with decreasing gonad weights. It must be borne in mind, however, that once spawning has taken place, fish are spent or declining to an inactive stage of gonad development and will not react to such stimuli, so that the increase in temperatures at this time in no way affects gonad activity. Temperatures of air, 0 metre and the 0–50 metre layer were high in May and may have stimulated the increase in gonad weights which occurred in June. Here again it must be emphasized that the state of the gonads and the stage of the physiological rhythm must be such that they are ready to react to an environmental stimulus, the point being that this may indeed occur since the gonads are probably in an inactive state, but fully able to start developing immediately for a period of one or two months. If a rise in water temperature occurs at the beginning of the period an early development of gonads and consequently an early spawning will take place. Early or late spawning may be important in relation to survival of eggs and larvae.

The rise in air temperature with consequent increase of surface temperatures in September may have stimulated spawning activity in St. Helena Bay to a small degree, as larger numbers of ova were recorded during this month.

In 1954 (see Plate 49, Fig. 3) air temperatures were somewhat erratic and were particularly high in March and June. In general, the surface and 0–50 metre temperatures showed similar trends and were never widely divergent.

The rise in surface and 0–50 metre temperatures in May possibly stimulated the increased gonad activity in that month and a rise in gonad weight from June onwards.

It seems possible therefore, that a rise in temperature of the surface and 0–50 metre layer in St. Helena Bay acts as a stimulus to increased gonad activity, and that it may influence the spawning season of the pilchard by causing it to be either early or late. Air temperature, although very closely linked with surface temperature, may undergo extensive changes before accompanying changes in water temperatures become apparent. The correlation of full meteorological data with sea temperatures would probably provide an explanation. Probably the most important effect of increased temperature in the St. Helena Bay area, where the majority of commercial catches of pilchards are made, is the initial stimulation of the gonads to start making. Later in the year the decrease in 0–50 metres, and to a certain extent 0 metre temperatures, from August and September onwards may be associated with an adverse reaction resulting in a migration of pilchards away from the area to some place where conditions are more favourable for spawning.

The mean temperature of the 0–50 metre layer is considered to be the best index of temperature in relation to the pilchard because it is likely that the fish spend the greater part of their time in St. Helena Bay within this depth of water.

In order to clarify further the relationship between sea temperature and gonad activity, the mean 0–50 metre temperature for St. Helena Bay was plotted graphically against the mean gonad weight of male and female pilchards combined for the years 1951 to 1954 inclusive (see Plates 51, 52 and Table 44).

From these graphs it appears that the sharp rise in temperature which took place in April, 1951 could have stimulated the start of a steady increase in gonad weight from May. The low temperatures of November and December may have been associated with a shorter spawning season and the decrease in gonad weight which occurred in January 1952.

In February 1953 the temperature was very low and from this month onwards gonad weights decreased sharply. A high temperature in April was followed by an increase in gonad weights from May, 1953.

Low temperature in January and February, 1954 were followed by decrease in gonad weights in March. Temperatures rising steadily to a maximum in May were followed by increase in gonad weight in June, 1954.

On the other hand, however, the direct opposite may occur, as seen in the sharp fall in temperature from April, 1953 which was followed by an increase in gonad weight in May, and the rise in temperature in February, 1954 which was followed by a decrease in gonad weights in March.

It is evident therefore, that gonad activity as shown by gonad weight follows a similar pattern of rise and fall each year which seems to be independent of the temperature.

The general relationship of gonad weight to temperature was obtained from the mean gonad weights of male and female pilchards combined for a period of four years (1951–1954) and the 0–50 metre mean temperatures for the same period (see Plate 52).

It is seen that during the summer months when temperature is low, gonad weights are high. In autumn temperature rises steeply while gonad weights fall sharply. During winter temperature is high and gonad weights are low and in spring while temperature is falling sharply from high to low, gonad weights are rising sharply from low to high. It is of interest to note, therefore, that the overall mean relationship between gonad weights and temperature (as shown by the mean of the 0–50 metre layer) is an inverse one.

(iii) Environmental Conditions Accompanying Spawning.

According to Tibby (1937) the minimum temperature at which spawning in the California sardine takes place is approximately 13° C, the optimum temperature for spawning lies between 15° and 18° C and spawning will occur at temperatures as high as 24° C. Ahlstrom (1954) confirmed the importance of 13° C as a threshold temperature for spawning but could not substantiate the optimum temperature range reported by Tibby. Ahlstrom found that most California sardine spawning occurred within a 4-degree temperature range, viz 12·5° C *and* 16·5° C; negligible amounts of spawning were found at temperatures below 12·5° C He concluded that the upper temperature limits were not very sharply defined, as " off-season " spawning had been found to occur at temperatures exceeding 20° C.

The ova of the South African pilchard have been recorded at temperatures between 11·9° and 21·7° C; those obtained at 11·9° C had been recently spawned. From an examination of the temperature records of all stations at which ova were recorded during the period March, 1950 to December, 1954, the following was concluded:—

(1) Less than 5 per cent of spawning occurred at temperatures between 11·0° and 12·9°C.

(2) Nearly 14 per cent of spawning occurred between 13·0° and 13·9° C.

(3) *Just over* 23 *per cent of spawning occurred between* 14·0° and 14·9° C.

(4) *Over* 30 *per cent of spawning occurred between* 15·0° *and* 15·9° C.

(5) Eleven per cent of spawning occurred between 16·0° and 16·9° C.

(6) Approximately 8 per cent of spawning occurred between 17·0° and 17·9° C.

(7) Five per cent of spawning occurred between 18·0° and 19·9° C.

(8) Four per cent of spawning occurred between 20·0° and 21·9° C.

Most of South African pilchard spawning (77 per cent) was therefore recorded between 13° and 17° C. Although the range of temperatures for spawning was between 11·9° and 21·7° C, most spawning which occurred over 17° C may be classified as " off-season " spawning. The four-degree range of maximum spawning from 13–17° C is virtually the same as that stated for the California sardine by Ahlstrom. Comparatively small numbers of ova were obtained below 12·5° C. All the above temperatures are for surface only.

Data on temperature and salinity for all routine offshore stations at which numbers of pilchard ova were in excess of 1000 per station were extracted during the four year period 1951–54. Temperatures and salinities at 0, 10 and 20 metre depths were extracted (see Table 43).

In most cases the surface plankton nets contained the majority of pilchard ova. There were frequent occasions, however, when approximately equal numbers were found in the 0 metre and oblique nets, and less frequently the oblique net contained more ova than the surface net. It seems likely, therefore, that pilchard ova are concentrated mainly at the surface and down to depths of 10 and 20 metres.

It will be seen from the data contained in Table 43 that the range of surface temperatures for intensive spawning lies between 13·0° C and 21·2° C with a mean of 15·4° C. While 13·0° C certainly appears to be a significant temperature for the start of large scale spawning, 21·2° C is an isolated high temperature. It is felt that 13° C *can be treated as an important minimum temperature in relation to major spawning activity.* This temperature coincides with Ahlstrom's threshold temperature for the spawning of the California sardine. *A mean temperature indicating the presence of conditions right for intensive spawning in the South African pilchard is given as* 15° *C,* the mean of the average temperatures for 0 metres to 10 metres where large numbers of ova were recorded being 15·1° C.

During 1954, however, more than three times as many pilchard ova were obtained from the offshore routine stations as in 1953. From Table 42 and Plate 50 it may be seen that during the month of February when the highest number of ova was

recorded, surface and air temperatures were high but the 0–50 metre mean temperature was rather low. Spawning probably occurred at or near the surface at a temperature of 21·2° C at station V where over 35,000 ova were obtained.

That larger numbers of ova were obtained from the routine offshore area during 1954 is ascribed to the fact that both surface and 0–50 metre average temperatures were unusually high.

The *salinities* recorded at stations where large numbers of ova were obtained may be seen in Table 43, and at 0 metres range from 34·5 to 35·4‰ and at 10 metres from 34·6 to 35·35‰. It is considered that the mean of the 0 metres and 10 metres salinities may be regarded as an index of conditions suitable for the spawning of the pilchard. This figure is 35·11‰.

In recent published work on fisheries biology and fisheries research in general, considerable emphasis has been laid on the effect of wind direction and velocity on the environment of fishes. There is no doubt that wind has a very marked effect on the pilchards of St. Helena Bay. There seems to be a definite connection between wind and local movement of the fish on- or offshore and the effect of prolonged winds is reflected in the changes in water temperatures and water movement in the bay and all the effects which accompany these changes. Unfortunately no detailed data on winds are available but it is hoped that at some time in the future it will be possible to correlate wind data with the behaviour of the pilchard.

Temperatures and salinities at depths of 0, 10 and 20 metres for every station at which ova were recorded during a single year (1954) were extracted, and graphed against egg densities (see Plates 53, 54 and 55 and Table 45). The year 1954 was chosen as it was the one in which the largest number of ova was recorded for the routine offshore stations. By this means it was intended to bring to light any important temperatures or salinities which might have been masked by the averages already mentioned in this section.

At 0 metres (see Plate 53) ova densities were rather widely scattered in relation to both temperature and salinity, the total range being from 21·2° C and 34·53‰ (35,320 ova) to 12·26° C and 34·79‰ (2 ova). The conditions of the maximum were very far removed from any others at which ova were obtained and appeared to be abnormal. The increase in temperature may have been encountered suddenly by ripe fish, causing an immediate spawning reaction. From the minimum conditions the numbers of ova gradually increased. *There appears to be very little correlation between ova densities, temperature and salinity at* 0 *metres.*

The largest number of recordings of ova and the greatest ova densities occurred between 14–16° C *and* 35·1–35·4‰ *at the surface.*

At 10 metres (see Plate 54) ova densities showed a definite trend in relation to temperature and salinity. A wide range was again evident due to the large number of ova recorded for one station at 19·86° C and 34·35‰. *The largest number of ova were, however, recorded between temperatures of* 13·8–15·8° C *and salinities of* 35·1–35·4‰ *at a depth of* 10 *metres.*

At 20 metres (see Plate 55) an even more definite trend or pattern of ova densities in relation to both temperature and salinity was evident. Although a wide range existed due to the same high temperature reflected in the 10 and 0 metres depths, a far closer grouping of the remainder took place. *The largest number of ova recordings and the highest densities for the* 20 *metre depth occurred at temperatures between* 13·8–16° C *and salinities between* 35·1–35·36‰.

It appears therefore that main spawning occurs within a temperature range of 13·8–16° C *and a salinity range of* 35·1–35·4‰, *and that at* 20 *metres there is definite correlation between ova densities, temperature and salinity.*

14. Reproduction of the Pilchard in the Union and in South West Africa.

General information on the reproductive activity of the pilchard in South West African waters was made available in the Second Pilchard Research Report (Matthews, 1955). This report covers the calendar year 1954 during which 60 samples consisting of 2,300 pilchards were examined. It was therefore possible to make a brief general comparison of the reproduction of the pilchard in the two areas.

(i) Condition of Gonads.

In South West Africa the seasonal trend in gonad development for 1954 was as follows: gonads were least active in autumn and early winter, began making in July, became active in early spring and summer and reached maximum activity in February and March. Some spent fish were recorded in late spring. No ripe and running females were obtained.

This trend in gonad development for 1954 was almost identical with the seasonal changes in the state of gonads recorded in the Union for the same period, but it is understood (Matthews, private communication) that very few gonads beyond stage 3 were recorded in the S.W. African fish.

(ii) Gonad Weight.

During 1954 in South West Africa gonad weights of male and female pilchards declined in March and April to reach a minimum in May. They increased from June through to August (the maximum mean weight of gonads was $\pm$ 4 gm for females and $\pm$ 3 gm for males), declined slightly in September and October and rose again in November.

The above trend was almost identical with that of mean gonad weight for the pilchard in the Union, but the increase in gonad weight for South West African fish was extremely small in comparison with that of the Union, and according to the graphs of mean gonad weights for S.W. Africa, no pilchards in the commercial catches possessed gonads which weighed enough for them to have come anywhere near to spawning.

(iii) Ova in the Plankton.

The recordings of pilchard eggs at the research stations off Walvis Bay in 1954 were as follows: pilchard eggs appeared in the plankton in late June and increased to a maximum in September, thereafter decreasing to nil by the end of October. These corresponded roughly to the recordings of pilchard eggs at the offshore routine stations in Union waters in 1954 when eggs were recorded in May and June and from August to December. According to the report, intensive spawning took place in S.W. African waters in September.

(iv) Condition Factor.

The condition factor for the S.W. African fish in the commercial catches for 1954 rose in April to reach a maximum in June and July and then declined to a minimum in September and October. During November and December it rose again. Mean K for Union pilchards was at a maximum in February and March and a minimum in August and September and did not show the same seasonal variations. It is not known whether the oil yield of the S.W. African fish is related to the condition factor.

The difference in the variation of K for the Union and South West African pilchards is probably due to the fact that the S.W. African pilchards are generally smaller and therefore likely to be younger than those caught off the West coast of the Union.

(v) Ratio of Sexes.

The mean ratio of sexes of the South West African commercial catches of pilchards for 1954 was approximately 55 per cent females and 45 per cent males. This corresponded almost exactly to the mean ratio of males to females in the commercial catches of the Union for 1954 which was 56:44.

The ratio of sexes in relation to length groups for the South West African fish shows a predominance of males from 17·5–20·4 cm standard lengths and an increasing predominance of females from 20·4–23·5 cm after which no males were recorded. From 23·5–25 cm only females were recorded.

These ratios differ from those recorded in the Union where neither sex predominated from 18–19 cm, males predominated from 19–22 cm and females predominated from 22–26 cm. The tendency for the presence of females only in the higher length groups was similar to the S.W. African fishery.

(vi) General.

It appears, therefore, *that the extent of the spawning season together with the period of maximum spawning activity for the pilchard are approximately the same for the Union and for South West Africa.* From the information available on gonad activity and weight, however, it seems very unlikely

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that the majority of pilchards comprising the commercial catches off South West Africa spawn at all. A comparison of the percentage frequency of the S.W. African catch for 1954 in relation to length group with the catches from Union waters from 1950–54 (see Plate 56) shows that the *S.W. African catches consist mainly of different size groups considerably smaller than those from Union waters.* The pilchard catches from S.W. Africa consist mainly of fish in length groups 19·5–22 cm while those from the Union fall in length groups 21–24 cm.

If the size at sexual maturity found for the Union fish is the same as that for the S.W. African pilchards, viz. ± 18·5 cm at first maturity, 50 per cent mature at ± 20 cm and 100 per cent mature at ± 22 cm then the possibility stated above that very few of the pilchards comprising the S.W. African commercial catches spawn at all, becomes almost a certainty. *It seems likely that a large proportion of pilchards caught in the commercial catches off Walvis Bay are not sexually mature.*

If there is a connection between the pilchard populations of the Union and South West Africa this aspect of the reproduction of the species is one of paramount importance due to the fact that the two fisheries are not controlled by the same administration. Consequently, extensive over-fishing off South West Africa (under the ideal conditions which prevail there) could lead to depletion of the Union's population of sexually mature fish which in turn might upset spawning with the result that permanent damage to the stock is done.

Tagging alone will provide the answer as to whether there is a connection between the pilchards of the Union and South West Africa, but the size composition and reproductive activity of the two populations make it most likely that the connection does exist.

The fact that spawning on a considerable scale takes place in South West African waters may be due to the activities of the comparatively small numbers of sexually mature fish present in the Walvis Bay area, or may be due to migration of larger sexually mature fish from the Union.

15. Conclusions.

In this section all the findings are briefly presented. Apart from the first item, viz. spawning season, the findings from each section in the paper are merely presented in shortened form since the results in greater detail will be found in the relevant sections in the text. In the first item, however, the findings from various sections have been combined and given in the form of conclusions in relation to the spawning season.

(i) Spawning Season (see Plate 57).

Spawning as indicated by the presence of pilchard ova in the plankton may take place during every month of the year. There is no doubt, however, that the finding of ova in St. Helena Bay and the immediate vicinity during many months of the year is incidental to the presence of large shoals of pilchards in these areas. Where so many fish are present it is almost inevitable that haphazard small scale spawning will occur.

In order to establish and define the main spawning season, evidence from every possible source was used including the gross assessment of gonad activity, gonad weights, ova diameters, condition factor and density of ova in the plankton.

From the gross assessment of the condition of gonads the main spawning season was shown to occur in the period *September to February* in each year. From gonad weight data main spawning occurred from *August to February* and from ova diameters main spawning was from *December to February* in the one year considered.

The largest numbers of ova were obtained in the plankton (see Table 46) during the period July to November and in January, February and March with maxima in September and February. The high ova count for July was due to a single large count obtained in 1953 and the counts for August were not particularly high in each year. Small ova counts obtained in December are due to the fact that pilchards are then generally absent from the area so that it is not unreasonable to include December in the spawning period. If July and August are discounted as main spawning months and December is included, the period of main spawning as indicated by ova in the plankton is from September to February.

Thus all the evidence reviewed above indicates that *the main spawning of the pilchard takes place in the period September to February* each year. This period is not rigidly fixed and intensive

spawning may begin early or late in different years. The intensity of spawning within the period is by no means constant and *sub-maxima may occur particularly in September and February.* These may be caused by the presence of large numbers of early spawners about to depart from the area of commercial fishing to the spawning grounds (September), and the return of spawning fish before the completion of spawning (February). Gonad weight data show that the larger fish spawn later than the small ones.

(ii) Spawning in Relation to the Commercial Catches.

During the period of nearly five years in which this study was made, only 108 female pilchards in a ripe and running state were obtained. Of these, 68 were obtained on a single occasion in July 1952. It may therefore be said that spawning pilchards are not normally found in the commercial catches of St. Helena Bay, and migrate elsewhere possibly to deeper water for purposes of spawning. Fairly large scale spawning has been recorded in St. Helena Bay (September and October, 1950) but this is not a frequent occurrence.

On the evidence at present available it would appear that the movement of pilchards away from St. Helena Bay in the early summer is a spawning migration.

(iii) Number of Ova per Female.

The examination of ovaries in an active state showed the presence of three types of ova. These were firstly, very small transparent ova of approximate diameter 0·2 mm which did not develop and were extruded during spawning. These ova appeared to have no function other than that of providing interstitial packing for the larger ova. Secondly, medium sized semi-opaque ova of approximate diameter 0·5 mm were present in fair numbers. Thirdly, large numbers of opaque ova of approximate diameter 1·1 mm were found.

Ova counts of the ovaries of female pilchards showed that *the numbers of ova increase with the increase in size of the fish* and *that the average number of ova per female was* 99,000 *ova.* It is estimated that *the average number of ova spawned per female is roughly* 95,000 *ova.*

In spite of the two size categories of the larger ova encountered viz. the 0·5 mm and the 1·1 mm diameter ova, it is considered that the smaller ova are those which are in a less advanced state of development than the others and that before the fish spawns they catch up with the bigger ones. The possibility of two spawnings per season seemed unlikely when it was found that stage 6 fish possessed ova, the majority of which were ripe and stage 7 fish ovaries which were almost completely evacuated.

(iv) Spawning in Relation to Environmental Conditions.

In the examination of environmental conditions associated with the reproductive activity of the pilchard it was concluded that sea temperatures were important in relation to spawning.

It was found that there was a definite relationship between the numbers of ova in the plankton, the sea temperature and the salinity. The lowest limit of temperature in which recently spawned pilchard ova were found was 11·9° C; the largest numbers of ova were found between temperatures of 14–16° C and salinities 35·1–35·4‰, and no ova were recorded beyond 21·7° C. The threshold temperature for major spawning activity was found to be 13° C, and a temperature of 15° C and salinity of 35·14‰ usually indicated conditions right for pilchard spawning.

(v) Size at Sexual Maturity.

The main length groups of pilchards comprising the commercial catches of the South African pilchard fishery are approximately 21–24 *cm.* It was found that these pilchards become sexually mature for the first time between 18–18·5 cm length. Fifty per cent of pilchards are mature at approximately 19 cm. and all fish are sexually mature between 20·5–22 cm. It is seen therefore, that *the majority of pilchards comprising the commercial catches of Union waters are sexually mature.*

(vi) Ratio of Sexes.

The mean ratio of males to females in the commercial catches of pilchards in Union waters is 44:56. This ratio does not remain steady for all sizes of fish, however, and in the smaller length groups below 19 cm the ratio varies in a haphazard fashion probably due to the small numbers of these

sizes obtained from the commercial catches. Between 19–22 cm the ratio of males to females is the opposite to the overall mean and becomes 56:44. Beyond 22·5 cm the numbers of female pilchards increase rapidly while the numbers of males decrease just as rapidly, showing that the majority of female pilchards grow to a larger maximum size than the males.

(vii) Condition Factor.

A calculation of the relationship of the weight to the length of the pilchard showed that for male pilchards the weight varies as the length to the power 2·928 and for female fish as the length to the power 2·808. For the South African pilchard, therefore, the weight increases at a rate less than the cube of its length. There is some variation of these rates in relation to the size of fish considered. It was nevertheless considered that the formula: condition factor $= \frac{\text{weight} \times 100}{\text{length}^3}$ was sufficiently accurate for general usage.

A comparison of the South African pilchard and the California sardine showed that the above indices of length variation in relation to weight were remarkably close but that the factor values for the pilchard were higher, thus showing the California sardine to be a fish having less weight per unit of length than the pilchard.

The condition factor for male and female pilchards virtually coincided for all fish at all sizes.

Fluctuations of condition factor were not found to be directly related to feeding or reproductive activities, but were possibly related to the fatness and oil content of the pilchard.

Condition factor was not related to the poor condition of pilchards known as *pap* fish.

Condition factor for the commercial catches of pilchards is high in summer, reaches a maximum in March, declines rapidly in autumn and winter to reach a minimum in August or September and begins to rise again in late spring.

(viii) Reproduction of the Pilchard in the Union and in South West Africa.

It appears that the spawning seasons for the pilchards in Union and in South West African waters are approximately the same. It is likely that a large proportion of pilchards caught commercially off Walvis Bay are not sexually mature fish.

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18. Appendix.

Tables of data on which text, figures and plates are based.

Table I.

Classification of Male Gonads—1950.

Month.	1	2	3	4	5	6	7	8	9	10	Total No. of Fish.
	i	ia	a	ar	r	rr	s	si	sia	Special.	
January.....	—	—	—	—	—	—	—	—	—	—	—
February.....	—	—	—	—	—	—	—	—	—	—	—
March.....	—	—	—	—	—	—	—	—	—	—	—
April.....	(32·2) 108	—	(35·8) 120	(3) 10	—	(0·3) 1	(26·6) 89	—	—	sa (2·1) = 7	335
May.....	(54·8) 280	(2·7) 14	(23·7) 121	(0·8) 4	—	—	(18) 92	—	—	—	511
June.....	(49) 252	(26) 133	(19·3) 99	(1·3) 7	—	(0·2) 1	(3) 16	—	—	sa (1·2) = 6	514
July.....	(48·6) 140	(23·6) 68	(24·3) 70	(2·8) 8	(0·7) 2	—	—	—	—	—	288
August.....	(36) 179	(16·3) 81	(29·2) 145	(9·9) 49	(8) 40	(0·4) 2	(0·2) 1	—	—	—	497
September.....	(13·5) 29	(16·7) 36	(45·1) 97	(7·4) 16	(12·6) 27	(4·2) 9	—	—	—	rudim = 1	215
October.....	(11·3) 16	(13·5) 19	(60·3) 85	(11·3) 16	(3·6) 5	—	—	—	—	—	141
November.....	(12·2) 51	(9·8) 41	(43·3) 181	(11·5) 48	(22·0) 92	(1·2) 5	—	—	—	—	418
December.....	(2·2) 2	—	(27·7) 25	(17·8) 16	(48·9) 44	(2·2) 2	(1·1) 1	—	—	—	90
										Total.....	3,009

N.B.—Figures in brackets indicate percentages of total number of fish per month.

TABLE 2.

CLASSIFICATION OF FEMALE GONADS—1950.

Month.	1	2	3	4	5	6	7	8	9	10	Total No. of Fish.
	i	ia	a	ar	r	rr	s	si	sia	Special.	
January.....	—	—	—	—	—	—	—	—	—	—	—
February.....	—	—	—	—	—	—	—	—	—	—	—
March.....	—	—	—	—	—	—	—	—	—	—	—
April.....	(22) 102	—	(10·8) 50	(2·4) 11	(3·9) 18	—	(51·4) 238	—	—	sa (9·5) = 44	463
May.....	(30·6) 234	(4·2) 32	(12·6) 96	(1·7) 13	(0·5) 4	—	(33·5) 256	—	—	sa (16·9) = 129	764
June.....	(39·2) 295	(32·0) 241	(7·8) 59	(4·1) 31	(0·7) 5	—	(11·7) 88	—	—	sa (4·5) = 34	753
July.....	(47·6) 191	(24·4) 98	(17·5) 70	(4·7) 19	(1·0) 4	—	(2·5) 10	—	—	sa (2·2) = 9	401
August.....	(33·9) 250	(21·9) 162	(24·8) 183	(13·8) 102	(4·3) 32	—	(0·7) 5	—	—	sa (0·5) = 4	738
September.....	(17·1) 61	(9·6) 34	(28·4) 101	(32·0) 114	(11·5) 41	—	(0·8) 3	(0·3) 1	—	sa (0·3) = 1	356
October.....	(15·0) 38	(18·1) 46	(35·4) 90	(28·3) 72	(0·8) 2	(0·4) 1	(1·2) 3	—	—	sa = 1 (0·4)	254
November.....	(19·3) 128	(10·9) 72	(30·5) 201	(23·5) 155	(12·0) 79	—	(1·2) 8	—	—	sa (2·6) = 17	660
December.....	(2·8) 3	(0·9) 1	(4·6) 5	(25·7) 28	(64·2) 70	—	—	—	—	sa = 1 (0·9) rs = 1 (0·9)	109
										TOTAL.....	4,498

N.B.—Figures in brackets indicate percentages of total number of fish per month.

TABLE 3.

CLASSIFICATION OF MALE GONADS—1951.

Month.	1	2	3	4	5	6	7	8	9	10	Total No. of Fish.
	i	ia	a	ar	r	rr	s	si	sia	Special.	
January.....	—	(13·3) 4	(16·7) 5	(23·3) 7	(40) 12	(6·7) 2	—	—	—	—	30
February.....	(7·8) 8	(3·9) 4	(37·2) 38	(21·6) 22	(26·5) 27	—	(2·0) 2	—	—	sa (1·0) = 1	102
March.....	(11·9) 26	(6·0) 13	(38·1) 83	(27·1) 59	(13·8) 30	—	(3·2) 7	—	—	—	218
April.....	(38·5) 120	(11·9) 37	(19·6) 61	(1·9) 6	(0·6) 2	—	(26·9) 84	—	—	sa = 1 (0·3) Undev. (0·3) = 1	312
May.....	(74·4) 320	(18·8) 81	(4·9) 21	(0·2) 1	—	—	(1·4) 6	—	—	Undev. = 1 (0·2)	430
June.....	(49) 165	(32) 108	(18·1) 61	—	—	—	(0·9) 3	—	—	—	337
July.....	(20) 109	(31·7) 173	(43·8) 239	(3·8) 21	(0·5) 3	—	(0·2) 1	—	—	—	546
August.....	(3·3) 13	(8·0) 31	(61·4) 239	(13·6) 53	(12·9) 50	—	(0·8) 3	—	—	—	389
September.....	(1·2) 1	(1·2) 1	(42·2) 35	(13·2) 11	(42·2) 35	—	—	—	—	—	83
October.....	—	—	—	—	—	—	—	—	—	—	—
November.....	(1·9) 6	(4·8) 15	(61·1) 190	(23·1) 72	(7·7) 24	—	—	—	—	Rudim = 4 (1·3)	311
December.....	(7·3) 6	(1·2) 1	(56·1) 46	(11·0) 9	(23·2) 19	—	—	—	—	Undev. = 1 (1·2)	82
										TOTAL.....	2,840

N.B.—Figures in brackets indicate percentages of total number of fish per month.

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TABLE 4.

CLASSIFICATION OF FEMALE GONADS—1951.

Month.	1	2	3	4	5	6	7	8	9	10	Total No. of Fish.
	i	ia	a	ar	r	rr	s	si	sia	Special.	
January.....	—	(4·7) 3	(6·3) 4	(57·8) 37	(26·6) 17	(4·7) 3	—	—	—	—	64
February.....	(8·2) 12	(2·7) 4	(40·8) 60	(17·0) 25	(21·8) 32	(1·4) 2	(2·0) 3	—	—	sa = 1 (0·7) n.r. = 8 (5·4)	147
March.....	(9·9) 33	(3·6) 12	(27·7) 92	(44·0) 146	(10·5) 35	(0·3) 1	(3·9) 13	—	—	—	332
April.....	(28) 122	(16·1) 70	(14) 61	(8·7) 38	(1·6) 7	—	(31·6) 138	—	—	—	436
May.....	(47·5) 282	(39·2) 233	(1·9) 11	(1·9) 11	—	—	(8·9) 53	—	—	sa = 4 (0·7)	594
June.....	(60·8) 292	(25·6) 123	(7·9) 38	(1·3) 6	—	—	(4·4) 21	—	—	—	480
July.....	(35·9) 291	(19·2) 156	(27·3) 221	(12·5) 101	(0·1) 1	—	(5·0) 41	—	—	—	811
August.....	(6·2) 38	(11·8) 72	(39·2) 239	(34·0) 207	(8·0) 49	—	(0·7) 4	—	—	—	609
September.....	(0·9) 1	(8·9) 10	(50·9) 57	(9·8) 11	(29·5) 33	—	—	—	—	—	112
October.....	—	—	—	—	—	—	—	—	—	—	—
November.....	(5·5) 21	(4·4) 17	(35·7) 137	(49) 188	(3·4) 13	—	(1·8) 7	—	—	Rudim = 1 (0·3)	384
December.....	(5·6) 7	(7·3) 9	(41·1) 51	(33·9) 42	(12·1) 15	—	—	—	—	—	124
										TOTAL.....	4,093

N.B.—Figures in brackets indicate percentages of total number of fish per month.

Table 5.

Classification of Male Gonads—1952.

Month.	1	2	3	4	5	6	7	8	9	10	Total No. of Fish.
	i	ia	a	ar	r	rr	s	si	sia	Special.	
January.....	(4·5) 3	(4·5) 3	(63·6) 42	(15·2) 10	(10·6) 7	—	—	—	—	Rudim = 1 (1·5)	66
February.....	(17·1) 63	(3·3) 12	(61·1) 225	(10·6) 39	(7·1) 26	—	(0·5) 2	—	—	Rudim = 1 (0·3)	368
March.....	(43·2) 201	(11·0) 51	(35·9) 167	(1·5) 7	(0·9) 4	—	(7·5) 35	—	—	—	465
April.....	(73·9) 356	(7·5) 36	(13·7) 66	(0·2) 1	—	—	(4·6) 22	—	—	sa = 1 (0·2)	482
May.....	(74·2) 350	(16·3) 77	(6·1) 29	—	—	—	(3·2) 15	—	—	sa = 1 (0·2)	472
June.....	(54·6) 230	(20·9) 88	(23·8) 100	—	—	—	(0·7) 3	—	—	—	421
July.....	(31·9) 191	(19·2) 115	(45·3) 271	(1·0) 6	(1·7) 10	—	(0·7) 4	(0·2) 1	—	—	598
August.....	(11·2) 40	(12·8) 46	(50·8) 182	(18·7) 67	(6·4) 23	—	—	—	—	—	358
September.....	(50) 1	(50) 1	—	—	—	—	—	—	—	—	2
October.....	—	—	(85·2) 23	(11·1) 3	(3·7) 1	—	—	—	—	—	27
November.....	(1·8) 6	(1·5) 5	(60·6) 200	(15·8) 52	(20·3) 67	—	—	—	—	—	330
December.....	—	—	—	—	—	—	—	—	—	—	—
										Total.....	3,589

N.B.—Figures in brackets indicate percentages of total number of fish per month.

TABLE 6.

CLASSIFICATION OF FEMALE GONADS—1952.

Month.	1	2	3	4	5	6	7	8	9	10	Total No. of Fish.
	i	ia	a	ar	r	rr	s	si	sia	Special.	
January.....	(11·3) 13	(0·9) 1	(47·0) 54	(30·4) 35	(10·4) 12	—	—	—	—	—	115
February.....	(11·4) 48	(4·7) 20	(44·3) 187	(31·3) 132	(7·3) 31	—	(0·9) 4	—	—	—	422
March.....	(40·3) 218	(5·7) 31	(20·9) 113	(11·5) 62	(0·7) 4	—	(17·7) 96	—	—	sa = 17 (3·1)	541
April.....	(64·7) 432	(1·9) 13	(3·6) 24	(2·1) 14	(0·4) 3	—	(22·2) 148	—	—	sa = 34 (5·1)	668
May.....	(60·2) 302	(4·2) 21	—	(0·4) 2	—	—	(27·7) 139	—	—	sa = 38 (7·5)	502
June.....	(50·6) 291	(17·0) 98	(14·6) 84	—	(0·2) 1	—	(10·3) 59	—	—	Rudim = 1 (0·2) sa = 41 (7·1)	575
July.....	(32·7) 245	(14·9) 112	(33·1) 248	(4·3) 32	(1·1) 8	(9·1) 68	(0·3) 2	—	—	sa = 35 (4·7)	750
August.....	(15·2) 74	(12·9) 63	(47·3) 231	(18·4) 90	(5·9) 29	—	(0·2) 1	—	—	—	488
September.....	—	(33·3) 2	(33·3) 2	(33·3) 2	—	—	—	—	—	—	6
October.....	(3·1) 1	—	(84·4) 27	(12·5) 4	—	—	—	—	—	—	32
November.....	(5·5) 19	(2·0) 7	(61·6) 213	(17·1) 59	(13·6) 47	—	(0·3) 1	—	—	—	346
December.....	—	—	—	—	—	—	—	—	—	—	—
										TOTAL.....	4,445

N.B.—Figures in brackets indicate percentages of total number of fish per month.

TABLE 7.

CLASSIFICATION OF MALE GONADS—1953.

Month.	1	2	3	4	5	6	7	8	9	10	Total No. of Fish.
	i	ia	a	ar	r	rr	s	si	sia	Special.	
January.....	(29·5) 13	(2·3) 1	(59·1) 26	(9·1) 4	—	—	—	—	—	—	44
February.....	(1·6) 4	(0·4) 1	(54·3) 138	(31·1) 79	(12·6) 32	—	—	—	—	—	254
March.....	(17·5) 46	(3·0) 8	(57·4) 151	(14·1) 37	(7·6) 20	—	(0·4) 1	—	—	—	263
April.....	(72·3) 73	(13·9) 14	(12·9) 13	—	—	—	(1·0) 1	—	—	—	101
May.....	(81·2) 224	(13·4) 37	(5·4) 15	—	—	—	—	—	—	—	276
June.....	(41·9) 111	(23·0) 61	(33·2) 88	—	—	—	(1·8) 5	—	—	—	265
July.....	(23·4) 44	(31·4) 59	(45·2) 85	—	—	—	—	—	—	—	188
August.....	(4·1) 8	(30·9) 60	(63·4) 123	(1·5) 3	—	—	—	—	—	—	194
September.....	(12) 24	(33·5) 67	(54) 108	(0·5) 1	—	—	—	—	—	—	200
October.....	(8·6) 3	(37·1) 13	(31·4) 11	—	—	—	—	(5·7) 2	(17·1) 6	—	35
November.....	(95) 19	—	—	—	(5) 1	—	—	—	—	—	20
December*....	(55·1) 75	(11·8) 16	(30·9) 42	—	—	—	—	—	(1·5) 2	sa = 1 (0·7)	136
										TOTAL.....	1,976

* Caught in False Bay.

N.B.—Figures in brackets indicate percentages of total number of fish per month.

TABLE 8.

CLASSIFICATION OF FEMALE GONADS—1953.

Month.	1	2	3	4	5	6	7	8	9	10	Total No. of Fish.
	i	ia	a	ar	r	rr	s	si	sia	Special.	
January.....	(48·2) 27	—	(17·9) 10	(33·9) 19	—	—	—	—	—	—	56
February.....	(3·2) 11	—	(41·6) 144	(41·9) 145	(13·0) 45	—	(0·3) 1	—	—	—	346
March.....	(25·8) 87	(6·8) 23	(42·1) 142	(8·9) 30	(8·0) 27	—	(8·3) 28	—	—	—	337
April.....	(67·8) 101	(12·8) 19	(12·1) 18	(1·3) 2	—	—	(6·0) 9	—	—	—	149
May.....	(88·3) 286	(3·4) 11	(2·5) 8	(0·3) 1	—	—	(5·6) 18	—	—	—	324
June.....	(62·3) 207	(16·3) 54	(18·4) 61	(0·3) 1	—	—	(2·4) 8	—	—	sa = 1 (0·3)	332
July.....	(28·2) 95	(29·1) 98	(41·2) 139	(0·9) 3	(0·3) 1	—	—	—	—	sa = 1 (0·3)	337
August.....	(26·6) 68	(30·5) 78	(42·6) 109	(0·4) 1	—	—	—	—	—	—	256
September.....	(28·8) 72	(32·8) 82	(32·0) 80	(2·4) 6	(0·4) 1	(0·4) 1	(2·4) 6	—	—	sa = 2 (0·8)	250
October.....	(2·2) 1	(34·8) 16	(30·4) 14	—	—	(10·9) 5	(2·2) 1	(2·2) 1	(15·2) 7	sa = 1 (2·2)	46
November.....	(84·6) 11	(7·7) 1	(7·7) 1	—	—	—	—	—	—	—	13
December*....	(65) 93	(14) 20	(14·7) 21	(1·4) 2	—	—	(0·7) 1	(1·4) 2	(2·8) 4	—	143
										TOTAL.....	2,589

* Caught in False Bay.

N.B.—Figures in brackets indicate percentages of total number of fish per month.

TABLE 9.

CLASSIFICATION OF MALE GONADS—1954.

Month.	1	2	3	4	5	6	7	8	9	10	Total No. of Fish.
	i	ia	a	ar	r	rr	s	si	sia	Special.	
January.....	(0·9) 1	(1·7) 2	(78·4) 91	(18·1) 21	(0·9) 1	—	—	—	—	—	116
February.....	—	(1·2) 1	(96·5) 82	(2·3) 2	—	—	—	—	—	—	85
March.....	(1·4) 2	(7·9) 11	(82·0) 114	(8·6) 12	—	—	—	—	—	—	139
April.....	(39·5) 87	(19·5) 43	(30·0) 66	(10·5) 23	—	—	—	—	—	sa = 1 (0·5)	220
May.....	(51·6) 174	(23·4) 79	(23·4) 79	(1·2) 4	—	—	—	—	(0·3) 1	—	337
June.....	(24·2) 53	(30·6) 67	(42·9) 94	(1·8) 4	—	—	(0·5) 1	—	—	—	219
July.....	(6·1) 15	(20·2) 50	(71·7) 177	(2·0) 5	—	—	—	—	—	—	247
August.....	(24) 18	(21·3) 16	(45·3) 34	(1·3) 1	—	—	(8) 6	—	—	—	75
September.....	(41·6) 37	(39·3) 35	(15·7) 14	(1·1) 1	—	—	—	—	(2·2) 2	—	89
October.....	(3·8) 8	(10·5) 22	(76·1) 159	(8·1) 17	—	—	—	—	(1·4) 3	—	209
November.....	—	—	(87·3) 48	(10·9) 6	—	—	—	—	—	undev. (1·8) = 1	55
December*....	—	—	(97·2) 35	(2·8) 1	—	—	—	—	—	—	36
										TOTAL.....	1,827

* Caught in False Bay.

N.B.—Figures in brackets indicate percentages of total number of fish per month.

TABLE 10.

CLASSIFICATION OF FEMALE GONADS—1954.

Month.	1	2	3	4	5	6	7	8	9	10	Total No. of Fish.
	i	ia	a	ar	r	rr	s	si	sia	Special.	
January.....	(1·1) 2	(10·3) 19	(82·1) 151	(2·7) 5	—	—	(1·1) 2	—	(1·6) 3	sa = 2 (1·1)	184
February.....	(6·3) 7	(12·5) 14	(77·7) 87	(3·6) 4	—	—	—	—	—	—	112
March.....	(16·1) 26	(10·6) 17	(71·4) 115	(0·6) 1	—	—	(1·2) 2	—	—	—	161
April.....	(69·3) 194	(14·3) 40	(7·9) 22	(0·4) 1	—	—	(7·5) 21	—	(0·4) 1	sa = 1 (0·4)	280
May.....	(84·8) 434	(7·6) 39	(3·3) 17	(0·4) 2	—	—	(3·7) 19	—	(0·2) 1	—	512
June.....	(62·2) 206	(23·6) 78	(13·3) 44	(0·6) 2	(0·3) 1	—	—	—	—	—	331
July.....	(36·6) 166	(29·1) 132	(30·9) 140	(1·3) 6	—	—	(1·3) 6	—	(0·7) 3	—	453
August.....	(43·3) 45	(14·4) 15	(30·8) 32	(1·0) 1	—	—	(10·6) 11	—	—	—	104
September.....	(67·8) 61	(11·1) 10	(15·6) 14	—	—	—	(3·5) 5	—	—	—	90
October.....	(18·8) 51	(19·1) 52	(53·7) 146	(1·5) 4	—	(0·7) 2	(0·4) 1	(4·4) 12	(1·5) 4	—	272
November.....	—	(1·1) 1	(95·8) 91	—	—	(3·1) 3	—	—	—	—	95
December*....	—	—	(78·9) 90	(14·9) 17	(2·6) 3	—	(2·6) 3	—	—	sa = 1 (0·9)	114
										TOTAL.....	2,708

* Caught in False Bay.

N.B.—Figures in brackets indicate percentages of total number of fish per month.

TABLE 11.

PERCENTAGES OF MALE PILCHARD GONADS AT STAGES 4, 5 AND 6 (i.e. ar, r AND rr RESPECTIVELY)—1950–54.

Month.	Stages 4, 5, 6 1950.	Stages 4, 5, 6 1951.	Stages 4, 5, 6 1952.	Stages 4, 5, 6 1953.	Stages 4, 5, 6 1954.
	Percentage.	Percentage.	Percentage.	Percentage.	Percentage.
January	—	70·0	25·8	9·1	19·0
February	—	48·1	17·7	43·7	2·3
March	—	40·9	2·4	21·7	8·6
April	3·3	2·5	0·2	Nil	10·5
May	0·8	0·2	Nil	Nil	1·2
June	1·5	Nil	Nil	Nil	1·8
July	3·5	4·3	2·7	Nil	2·0
August	18·3	26·5	25·1	1·5	1·3
September	24·2	55·4	Closed Season	0·5	1·1
October	14·9	Closed Season	14·8	Nil	8·1
November	34·7	30·8	36·1	5·0	10·9
December	68·9	34·2	—	Nil	2·8(F.B.)

F.B. = False Bay.

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TABLE 12.

PERCENTAGES OF FEMALE PILCHARD GONADS AT STAGES 4, 5 AND 6 (i.e. ar, r AND rr RESPECTIVELY)—1950–54.

Month.	Stages 4, 5, 6 1950.	Stages 4, 5, 6 1951.	Stages 4, 5, 6 1952.	Stages 4, 5, 6 1953.	Stages 4, 5, 6 1954.
	Percentage.	Percentage.	Percentage.	Percentage.	Percentage.
January	—	89·1	40·8	33·9	2·7
February	—	40·2	38·6	54·9	3·6
March	—	54·8	12·2	16·9	0·6
April	6·3	10·3	2·5	1·3	0·4
May	2·2	1·9	0·4	0·3	0·4
June	4·8	1·3	0·2	0·3	0·9
July	5·7	12·6	14·5	1·2	1·3
August	18·1	42·0	24·3	0·4	1·0
September	43·5	39·3	33·3	3·2	Closed Season
October	29·5	Closed Season	12·5	10·9	2·2
November	35·5	52·4	30·7	Closed Season	3·1
December	89·9	46·0	—	1·4(F.B.) Closed Season	17·5(F.B.)

F.B. = False Bay.

TABLE 13.

MATURITY OF MALE PILCHARDS—1950–51.

Standard Length.	January, 1951.			February.			December.			Total Numbers		Percentage.
	Inac.	Act.	Total.	Inact.	Act.	Total.	Inac.	Act.	Total.	Inact.	Act.	Act.
cm												
14·0–14·4	—	—	—	—	—	—	—	—	—	—	—	—
14·5–14·9	—	—	—	—	—	—	—	—	—	—	—	—
15·0–15·4	—	—	—	—	—	—	—	—	—	—	—	—
15·5–15·9	—	—	—	—	—	—	—	—	—	—	—	—
16·0–16·4	—	—	—	—	—	—	—	—	—	—	—	—
16·5–16·9	—	—	—	—	—	—	1	—	1	1	—	0
17·0–17·4	—	—	—	—	—	—	—	—	—	—	—	—
17·5–17·9	—	—	—	—	—	—	—	—	—	2	—	0
18·0–18·4	—	—	—	2	—	2	—	—	—	2	—	0
18·5–18·9	—	—	—	2	—	2	—	—	—	2	—	0
19·0–19·4	—	—	—	—	—	—	—	—	—	—	—	—
19·5–19·9	—	—	—	1	1	2	—	2	2	1	3	75
20·0–20·4	—	—	—	1	4	5	—	2	2	1	6	86
20·5–20·9	—	—	—	—	3	3	1	10	11	1	13	93
21·0–21·4	—	1	1	1	9	10	—	7	7	1	17	95
21·5–21·9	—	3	3	—	9	9	—	9	9	—	21	100
22·0–22·4	—	5	5	—	20	20	—	12	12	—	17	100
22·5–22·9	—	10	10	—	21	21	—	19	19	—	29	100
23·0–23·4	—	8	8	—	22	22	—	22	22	—	30	100
23·5–23·9	—	2	2	—	4	4	—	6	6	—	12	100
24·0–24·4	—	—	—	—	1	1	—	4	4	—	5	100
24·5–24·9	—	—	—	—	1	1	—	2	2	—	3	100
25·0–25·4	—	—	—	—	—	—	—	—	—	—	—	100
25·5–25·9	—	—	—	—	—	—	—	—	—	—	—	—
26·0–26·4	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	—	29	29	7	95	102	2	95	97	11	156	

TABLE 14.

MATURITY OF FEMALE PILCHARDS—1950–51.

Standard Length.	January, 1951.			February.			December.			Total Numbers.		Percentage.
	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Active.
cm												
14·0–14·4.....	—	—	—	—	—	—	—	—	—	—	—	—
14·5–14·9.....	—	—	—	—	—	—	—	—	—	—	—	—
15·0–15·4.....	—	—	—	—	—	—	—	—	—	—	—	—
15·5–15·9.....	—	—	—	1	—	1	—	—	—	1	—	0
16·0–16·4.....	—	—	—	—	—	—	—	—	—	—	—	—
16·5–16·9.....	—	—	—	3	—	3	—	—	—	3	—	0
17·0–17·4.....	—	—	—	—	—	—	—	—	—	—	—	—
17·5–17·9.....	—	—	—	—	—	—	—	—	—	—	—	—
18·0–18·4.....	—	—	—	1	—	1	—	—	—	1	—	0
18·5–18·9.....	—	—	—	1	—	1	—	—	—	1	—	0
19·0–19·4.....	—	—	—	1	—	1	—	—	—	1	—	0
19·5–19·9.....	1	—	1	1	—	1	1	1	2	3	1	25
20·0–20·4.....	—	2	2	—	1	1	—	2	2	—	5	100
20·5–20·9.....	—	3	3	1	1	2	—	3	3	1	7	88
21·0–21·4.....	—	3	3	—	8	8	—	2	2	—	13	100
21·5–21·9.....	—	3	3	1	4	5	—	3	3	1	10	91
22·0–22·4.....	—	2	2	—	16	16	—	4	4	—	22	100
22·5–22·9.....	—	12	12	1	15	16	—	12	12	1	39	98
23·0–23·4.....	—	11	11	—	25	25	—	15	15	—	49	100
23·5–23·9.....	—	16	16	—	29	29	—	19	19	—	64	100
24·0–24·4.....	—	4	4	—	21	21	—	12	12	—	37	100
24·5–24·9.....	—	3	3	—	9	9	—	7	7	—	19	100
25·0–25·4.....	—	1	1	—	7	7	—	5	5	—	13	100
25·5–25·9.....	—	3	3	—	1	1	—	—	—	—	4	100
26·0–26·4.....	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL.....	1	63	64	11	137	148	1	85	86	13	283	

Table 15.

Maturity of Male Pilchards—1953.

Standard Length.	January			February.			October.			November.			December.			Total Numbers.		Percentage Active.
	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	
cm																		
12·5–12·9.	—	—	—	—	—	—	—	—	—	2	—	2	—	—	—	2	—	0
13·0–13·4.	—	—	—	—	—	—	—	—	—	3	—	3	—	—	—	3	—	0
13·5–13·9.	—	—	—	—	—	—	—	—	—	4	—	4	—	—	—	4	—	0
14·0–14·4.	—	—	—	—	—	—	—	—	—	5	—	5	1	—	1	6	—	0
14·5–14·9.	—	—	—	—	—	—	—	—	—	2	—	2	2	—	2	4	—	0
15·0–15·4.	—	—	—	—	—	—	—	—	—	1	—	1	10	—	10	11	—	0
15·5–15·9.	—	—	—	—	—	—	—	—	—	1	—	1	15	—	15	16	—	0
16·0–16·4.	—	—	—	—	—	—	—	—	—	1	—	1	7	—	7	8	—	0
16·5–16·9.	—	—	—	—	—	—	—	—	—	—	—	—	11	—	11	11	—	0
17·0–17·4.	—	—	—	—	—	—	—	—	—	—	—	—	10	—	10	10	—	0
17·5–17·9.	—	—	—	—	—	—	—	—	—	—	—	—	9	—	9	9	—	0
18·0–18·4.	—	—	—	—	—	—	—	—	—	—	—	—	13	2	15	13	2	13
18·5–18·9.	—	—	—	—	1	1	—	—	—	—	—	—	6	—	6	6	1	14
19·0–19·4.	—	1	1	1	4	5	—	—	—	—	—	—	—	5	5	1	10	91
19·5–19·9.	—	2	2	—	6	6	—	—	—	—	—	—	1	2	3	1	10	91
20·0–20·4.	—	1	1	1	23	24	—	—	—	—	—	—	—	4	4	1	28	97
20·5–20·9.	—	3	3	—	32	32	—	4	4	—	—	—	—	2	2	—	41	100
21·0–21·4.	—	7	7	—	51	51	—	4	4	—	—	—	—	12	12	—	74	100
21·5–21·9.	—	3	3	—	49	49	—	4	4	—	1	1	—	6	6	—	63	100
22·0–22·4.	—	4	4	—	40	40	—	7	7	—	1	1	2	7	9	2	59	97
22·5–22·9.	—	1	1	—	20	20	—	7	7	—	1	1	—	1	1	—	30	100
23·0–23·4.	—	3	3	—	11	11	1	5	6	—	—	—	—	—	—	—	19	100
23·5–23·9.	—	—	—	—	11	11	—	1	1	—	—	—	—	—	—	—	12	100
24·0–24·4.	—	—	—	—	1	1	—	2	2	—	—	—	—	—	—	—	3	100
24·5–24·9.	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	100
25·0–25·4.	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	100
25·5–25·9.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total....	—	25	25	2	251	253	1	34	35	19	3	22	87	41	128	108	354	

Reprint from "Commerce & Industry", April, 1956

Table 16.

Maturity of Female Pilchards—1953.

Standard Length.	January.			February.			October.			November.			December.			Total Numbers.		Percentage Active.
	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	
cm																		
12·5–12·9.	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	1	—	0
13·0–13·4.	—	—	—	—	—	—	—	—	—	3	—	3	—	—	—	3	—	0
13·5–13·9.	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	1	—	0
14·0–14·4.	—	—	—	—	—	—	—	—	—	3	—	3	—	—	—	3	—	0
14·5–14·9.	—	—	—	—	—	—	—	—	—	2	—	2	6	—	6	8	—	0
15·0–15·4.	—	—	—	—	—	—	—	—	—	1	—	1	9	—	9	10	—	0
15·5–15·9.	—	—	—	—	—	—	—	—	—	—	—	—	14	—	14	14	—	0
16·0–16·4.	—	—	—	—	—	—	—	—	—	—	—	—	13	—	13	13	—	0
16·5–16·9.	—	—	—	—	—	—	—	—	—	—	—	—	4	—	4	4	—	0
17·0–17·4.	—	—	—	—	—	—	—	—	—	—	—	—	8	—	8	8	—	0
17·5–17·9.	—	—	—	—	—	—	—	—	—	—	—	—	7	—	7	7	—	0
18·0–18·4.	—	—	—	—	—	—	—	—	—	—	—	—	13	—	13	13	—	0
18·5–18·9.	—	—	—	1	1	2	—	—	—	—	—	—	11	—	11	12	1	8
19·0–19·4.	—	—	—	—	4	4	—	—	—	—	—	—	11	4	15	11	8	42
19·5–19·9.	—	1	1	1	5	6	—	—	—	—	—	—	1	—	1	2	6	75
20·0–20·4.	—	1	1	1	11	12	—	—	—	—	—	—	—	4	4	1	16	94
20·5–20·9.	—	2	2	—	20	20	—	—	—	—	—	—	—	2	2	—	24	100
21·0–21·4.	—	3	3	—	35	35	1	2	3	—	—	—	—	5	5	1	45	98
21·5–21·9.	—	3	3	—	48	50	—	6	6	—	1	1	—	9	9	—	67	100
22·0–22·4.	—	8	8	2	66	68	—	7	7	—	—	—	—	8	8	2	89	98
22·5–22·9.	—	5	5	1	58	59	—	7	7	—	1	1	—	3	3	1	67	98
23·0–23·4.	—	2	2	—	29	29	—	8	8	—	—	—	—	—	—	—	39	100
23·5–23·9.	—	—	—	—	31	31	—	7	7	—	—	—	—	1	1	—	39	100
24·0–24·4.	—	—	—	—	20	20	—	6	6	—	—	—	—	—	—	—	20	100
24·5–24·9.	—	—	—	—	8	8	—	2	2	—	—	—	—	—	—	—	8	100
25·0–25·4.	—	—	—	—	3	3	—	—	—	—	—	—	—	—	—	—	3	100
25·5–25·9.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total...	—	25	25	6	339	345	1	45	46	11	2	13	97	36	133	109	93	

TABLE 17.

MATURITY OF MALE PILCHARDS—1952 (EXCLUDING STAGE A FISH).

Standard Length.	January.			February.			September.			October.			November.			Total Numbers.		Percentage Active.
	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	
cm																		
16·0–16·4.	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	1	—	0
16·5–16·9.	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2	2	—	0
17·0–17·4.	—	—	—	3	—	3	—	—	—	—	—	—	1	—	3	4	—	0
17·5–17·9.	2	—	4	13	—	14	—	—	—	—	—	—	1	—	9	16	—	0
18·0–18·4.	1	—	7	21	—	28	—	—	—	—	—	—	—	—	10	22	—	0
18·5–18·9.	—	1	5	13	—	31	—	—	—	—	—	—	—	—	11	13	1	7
19·0–19·4.	—	—	6	6	—	37	—	—	—	—	1	5	—	2	20	6	3	33
19·5–19·9.	1	—	7	4	—	25	1	—	1	—	—	7	—	6	30	6	6	50
20·0–20·4.	—	—	6	1	3	18	—	—	1	—	—	3	—	12	30	1	15	94
20·5–20·9.	—	2	4	—	—	23	—	—	—	—	—	1	—	4	12	—	6	100
21·0–21·4.	—	4	6	—	9	36	—	—	—	—	1	5	—	13	33	—	27	100
21·5–21·9.	—	—	1	—	5	38	—	—	—	—	1	3	—	11	32	—	17	100
22·0–22·4.	—	5	10	—	16	38	—	—	—	—	—	1	—	27	44	—	48	100
22·5–22·9.	—	2	4	1	13	36	—	—	—	—	—	—	—	15	27	1	30	97
23·0–23·4.	—	1	3	—	11	26	—	—	—	—	—	—	—	14	18	—	26	100
23·5–23·9.	—	3	3	—	5	13	—	—	—	—	2	2	—	9	9	—	19	100
24·0–24·4.	—	—	—	—	3	5	—	—	—	—	—	—	—	1	1	—	4	100
24·5–24·9.	—	—	—	—	1	1	—	—	—	—	—	—	—	1	1	—	2	100
25·0–25·4.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25·5–25·9.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL...	4	18	66	62	66	372	1	—	2	—	5	27	5	115	293	72	204	

Reprint from "Commerce & Industry", April, 1956

Table 18.

Maturity of Female Pilchards—1952 (excluding Stage A Fish).

Standard Length.	January.			February.			September.			October.			November.			Total Numbers.		Percentage Active.
	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	
cm																		
16·0–16·4.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16·5–16·9.	—	—	—	—	—	—	—	—	—	—	—	—	5	—	5	5	—	0
17·0–17·4.	4	—	5	—	—	2	—	—	—	—	—	—	3	—	4	7	—	0
17·5–17·9.	2	—	3	4	—	5	—	—	—	—	—	—	4	—	7	10	—	0
18·0–18·4.	3	—	4	8	—	11	—	—	—	—	—	—	3	—	8	14	—	0
18·5–18·9.	1	—	9	17	—	35	—	—	—	—	—	—	2	—	13	20	—	0
19·0–19·4.	—	—	3	8	1	26	—	—	—	—	—	—	—	3	19	8	4	33
19·5–19·9.	1	1	5	6	2	27	—	—	—	1	—	2	—	3	18	8	6	43
20·0–20·4.	—	1	12	2	9	28	—	—	—	—	—	4	—	6	22	2	16	89
20·5–20·9.	—	5	7	—	7	17	—	—	—	—	1	3	—	8	28	—	21	100
21·0–21·4.	—	2	3	—	9	18	—	—	1	—	—	2	—	8	31	—	19	100
21·5–21·9.	1	7	12	—	9	22	—	1	1	—	1	8	—	7	29	1	25	96
22·0–22·4.	—	5	15	—	11	30	—	—	—	—	—	2	—	14	41	—	30	100
22·5–22·9.	—	7	11	1	23	48	—	—	—	—	1	4	—	12	31	1	43	98
23·0–23·4.	—	7	9	—	37	65	—	—	—	—	—	3	1	12	32	1	56	98
23·5–23·9.	—	5	7	—	39	47	—	—	2	—	—	1	—	20	31	—	64	100
24·0–24·4.	—	4	6	—	19	29	—	—	1	—	—	3	—	8	14	—	31	100
24·5–24·9.	—	1	1	—	4	10	—	1	1	—	—	—	—	5	7	—	11	100
25·0–25·4.	—	1	1	—	4	5	—	—	—	—	—	—	—	3	5	—	8	100
25·5–25·9.	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	100
Total...	12	46	113	46	175	426	—	2	6	1	3	32	18	109	345	77	336	

TABLE 19.

MATURITY OF MALE PILCHARDS—1954 (EXCLUDING STAGE A FISH).

Standard Length.	January.			February.			November.			Total Numbers.		Percentage.
	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Active.
cm												
17·0–17·4	—	—	—	—	—	—	—	—	—	—	—	—
17·5–17·9	—	—	—	—	—	—	—	—	—	—	—	—
18·0–18·4	1	—	1	—	—	—	—	—	—	1	—	0
18·5–18·9	—	—	1	—	—	—	—	—	—	—	—	—
19·0–19·4	—	—	2	—	—	—	—	—	—	—	—	—
19·5–19·9	—	—	4	—	—	5	—	—	—	—	—	—
20·0–20·4	—	—	4	—	—	5	—	—	2	—	—	—
20·5–20·9	—	—	5	—	—	1	—	—	11	—	—	—
21·0–21·4	—	3	18	—	—	12	—	1	11	—	4	100
21·5–21·9	—	7	29	—	—	21	—	1	12	—	8	100
22·0–22·4	—	4	25	—	1	24	—	2	9	—	7	100
22·5–22·9	—	5	15	—	1	12	—	—	4	—	6	100
23·0–23·4	—	2	9	—	—	5	—	2	5	—	4	100
23·5–23·9	—	—	1	—	—	—	—	—	—	—	1	100
24·0–24·4	—	1	2	—	—	—	—	—	—	—	1	100
24·5–24·9	—	—	—	—	—	—	—	—	—	—	—	—
25·0–25·4	—	—	—	—	—	—	—	—	—	—	—	—
25·5–25·9	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	1	22	116	—	2	85	—	6	54	1	31	

TABLE 20.

MATURITY OF FEMALE PILCHARDS—1954 (EXCLUDING STAGE A FISH).

Standard Length.	January.			February.			November.			Total Numbers.		Percentage.
	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Total.	Inac.	Act.	Active.
cm												
17·0–17·4	—	—	—	—	—	—	—	—	—	—	—	—
17·5–17·9	—	—	—	—	—	—	—	—	—	—	—	—
18·0–18·4	—	—	—	—	—	—	—	—	—	—	—	—
18·5–18·9	—	—	—	—	—	—	—	—	—	—	—	—
19·0–19·4	—	—	—	—	—	—	—	—	—	—	—	—
19·5–19·9	—	—	—	1	—	2	—	—	—	1	—	0
20·0–20·4	—	—	—	3	—	5	—	—	—	3	—	0
20·5–20·9	—	—	8	—	—	3	—	—	5	—	—	—
21·0–21·4	1	—	11	—	—	9	—	2	10	1	2	67
21·5–21·9	—	—	18	1	—	8	—	—	18	1	—	0
22·0–22·4	—	3	40	1	—	28	—	—	18	1	3	75
22·5–22·9	—	1	42	1	1	24	—	1	17	1	3	75
23·0–23·4	1	1	48	—	1	19	—	2	17	1	4	80
23·5–23·9	—	—	10	—	1	12	—	—	8	—	1	100
24·0–24·4	—	1	5	—	—	1	—	—	2	—	1	100
24·5–24·9	—	1	3	—	—	—	—	—	—	—	1	100
25·0–25·4	—	—	—	—	—	—	—	—	—	—	—	—
25·5–25·9	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	2	7	185	7	3	111	—	5	95	9	15	

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Table 21.

Condition of Gonads of Pilchards under Lower Limit of Commercial Catch Size Caught by Research Vessels during the Period 27/2/51–10/11/53.

Sample Number.	Season.	Male.			Female.		
		Lc.	Mat.	Gonad Weight.	Lc.	Mat.	Gonad Weight.
		cm		gm	cm		gm
96	Summer.....	16·5	i	0·2	16·6	i	0·1
		16·1	i	0·2	16·9	i	0·1
		15·9	i	0·1	16·5	i	0·1
		—	—	—	15·9	i	0·1
300	Autumn.....	16·0	i	0·2	15·7	i	0·2
		15·6	i	0·2	16·1	i	0·2
		—	—	—	16·1	i	0·2
288		16·4	i	0·6	—	—	—
		16·2	i	0·2	—	—	—
		15·8	i	0·3	—	—	—
142	Winter.....	14·3	i	0·1	—	—	—
		16·0	i	0·1	—	—	—
		15·9	i	0·2	—	—	—
		14·4	i	0·1	—	—	—
		14·6	i	0·1	—	—	—
219		12·2	i	0·1	13·0	i	0·1
		12·3	i	0·1	13·0	i	0·1
		14·0	i	0·1	16·0	i	0·1
		14·5	i	0·1	14·1	i	0·1
		14·6	i	0·1	14·5	i	0·1
		—	—	—	15·7	i	0·2
313		16·3	i	0·3	16·4	i	0·4
		—	—	—	16·1	i	0·3
		—	—	—	15·8	i	0·2
		—	—	—	16·3	i	0·3
		—	—	—	16·7	i	0·5
		—	—	—	16·0	i	0·2
131	Spring.....	15·8	i	0·6	15·9	i	0·7
		—	—	—	16·6	i	0·5
		—	—	—	14·7	i	0·4
		—	—	—	16·9	i	0·7
142		14·0	i	0·2	14·3	i	0·1
349		15·1	i	0·1	16·0	i	0·1
		14·8	i	0·2	14·4	i	0·1
		15·8	i	0·3	14·6	i	0·1
		16·0	i	0·2	15·9	i	0·2

TABLE 22.—GONAD WEIGHTS IN RELATION TO MATURITY.

Stage.	Sex.	Year.	Mean Gonad Weights in Grams.										
			June.	July.	August.	September.	October.	November.	December.	Year.	January.	February.	March.
1	M.	1950	—	—	0·4	1·0	—	—	—	1951	—	—	—
	M.	1951	—	—	0·3	—	—	2·0	4·2	1952	1·2	0·6	0·6
	M.	1952	—	—	—	—	—	2·8	—	1953	—	—	—
	M.	1953	—	—	—	—	—	—	—	1954	—		—
	M.	1954	—	—	1·0	—	—	—	—				
Mean.....	M.		—	—	0·6	1·0	—	2·4	4·2		1·2	0·6	0·6
1	F.	1950	—	—	—	—	—	—	—	1951	—	—	0·2
	F.	1951	—	0·6	1·4	—	—	1·8	3·4	1952	0·8	0·6	0·6
	F.	1952	—	0·6	—	—	—	1·7	—	1953	—	—	—
	F.	1953	—	—	—	—	—	—	—	1954	—		—
	F.	1954	—	—	—	—	1·8	—	—				
Mean.....	F.		—	0·6	1·4	—	1·8	1·8	3·4		0·8	0·6	0·4
2	M.	1950	—	—	0·5	1·3	1·1	2·0	7·4	1951	—	1·1	1·1
	M.	1951	—	0·6	1·1	4·4	7·0	4·8	5·5	1952	5·9	3·7	0·9
	M.	1952	—	0·9	1·8	3·6	4·4	5·7	—	1953	2·5	3·7	0·7
	M.	1953	1·4	—	3·8	1·9	—	—	3·3	1954	5·7	5·8	2·4
	M.	1954	—	3·5	3·0	3·8	3·7	—	6·6				
Mean.....	M.		1·4	1·7	2·0	3·0	4·1	4·2	5·7		4·7	3·6	1·3
2	F.	1950	—	—	0·5	0·9	1·0	2·1	0·3	1951	—	0·4	0·5
	F.	1951	—	0·8	1·0	1·6	2·0	3·6	5·1	1952	4·7	2·9	1·2
	F.	1952	—	1·0	1·5	—	2·8	4·3	—	1953	1·7	3·0	2·1
	F.	1953	1·3	1·4	—	3·0	1·0	—	1·2	1954	—	2·2	0·4
	F.	1954	—	1·5	—	3·1	3·3	—	6·6				
Mean.....	F.		1·3	1·2	1·0	2·2	2·0	3·3	3·3		3·2	2·1	1·1
3	M.	1950	—	—	2·9	5·6	4·9	6·1	7·0	1951	9·4	6·3	3·7
	M.	1951	—	2·8	5·4	6·9	6·9	7·3	6·7	1952	8·3	8·2	3·3
	M.	1952	—	3·0	5·7	—	5·2	8·5	—	1953	8·1	8·7	1·5
	M.	1953	3·8	5·3	6·5	6·1	8·1	—	9·5	1954	9·0	10·1	5·4
	M.	1954	—	3·7	3·3	2·7	6·1	10·1	8·5				
Mean.....	M.		3·8	3·7	4·8	5·3	6·2	8·0	7·9		8·7	8·3	3·5
3	F.	1950	—	—	1·9	3·9	3·0	3·3	5·5	1951	6·2	11·3	3·1
	F.	1951	—	1·8	3·6	4·0	5·3	5·6	7·1	1952	8·0	6·3	2·4
	F.	1952	—	2·4	3·5	—	5·9	6·9	—	1953	7·3	7·3	3·4
	F.	1953	2·9	3·4	5·3	4·9	6·6	8·8	6·5	1954	7·1	5·4	3·1
	F.	1954	—	2·6	3·0	3·0	4·7	9·3	7·0				
Mean.....	F.		2·9	2·6	3·5	4·0	5·1	6·8	6·5		7·2	7·6	3·0
4	M.	1950	—	—	8·7	12·0	9·2	11·2	11·6	1951	15·1	12·4	12·2
	M.	1951	—	6·4	10·9	11·3	9·1	12·2	13·7	1952	13·2	12·9	5·8
	M.	1952	—	6·8	9·2	—	10·4	14·5	—	1953	12·4	12·2	10·8
	M.	1953	5·5	8·2	8·0	6·9	12·2	16·7	9·7	1954	14·0	13·3	10·4
	M.	1954	—	6·0	4·8	3·2	10·4	13·5	8·4				
Mean.....	M.		5·5	6·9	8·3	8·4	10·3	13·6	10·9		15·4	12·7	9·8
4	F.	1950	—	—	5·5	7·7	7·5	7·7	10·1	1951	13·8	14·2	10·6
	F.	1951	—	4·5	8·3	9·0	9·4	10·8	10·7	1952	13·1	11·2	7·1
	F.	1952	—	5·5	7·6	—	6·5	10·6	—	1953	7·2	12·1	6·8
	F.	1953	5·5	6·9	7·2	6·6	10·3	5·6	7·5	1954	10·1	10·8	10·5
	F.	1954	—	4·8	4·4	3·9	6·6	11·7	10·4				
Mean.....	F.		5·5	5·4	6·6	6·8	8·1	9·3	9·7		11·1	12·1	8·8

EXPLANATION.

Mean gonad weights for male and female pilchards were taken in length groups according to their size at different stages of sexual maturity:—

Stage.	*Lc Males cm*	*Lc Females cm*
(1) Immature.....	18 and under.	18·5 and under.
(2) 50 per cent mature	18·5–19·9	19·0–19·9
(3) Small mature...	20·0–21·9	20·0–21·9
(4) Large mature...	22 and over.	22 and over.

The mean gonad weights were taken over the period of the total extent of activity for each year—see page 421 of report.

TABLE 22 (*a*).

NUMBERS OF PEAKS OF GONAD WEIGHT (EXTRACTED FROM PLATES 14–27) PER MATURITY STAGE (1–4) FOR THE PERIOD, 1950–54.

Stage.	Length.	1950.	1951.	1952.	1953.	1954.	1950–54. Combined Total.
	cm						
1	18·5 and less	—	3 Dec.	1 Nov.	1 Sept.	1 Sept. 1 Oct.	Sept. 2 Oct. 1 Nov. 1 Dec. 3
2	19·0–19·9	1 Nov.	1 Nov. 1 Dec.	2 Nov. 2 Jan.	1 Jan. 1 Feb.	2 Dec.	Nov. 4 Dec. 3 Jan. 3 Feb. 1
3	20·0–21·9	1 Sept. 4 Dec.	3 Dec. 1 Jan. 3 Feb.	1 Oct. 3 Nov. 4 Jan. 1 Feb.	1 Oct. 2 Dec. 3 Jan. 2 Feb.	3 Nov. 1 Dec. 3 Jan.	Sept. 1 Oct. 2 Nov. 6 Dec. 10 Jan. 11 Feb. 6
4	22 and over	3 Sept. 1 Oct. 6 Dec. 3 Mar.	3 Sept. 2 Oct. 1 Nov. 3 Dec. 5 Jan. 3 Feb. 1 Mar.	1 Oct. 6 Nov. 6 Dec.* 7 Jan. 5 Feb.	1 July 1 Aug. 6 Oct. 3 Jan. 7 Feb.	1 Oct. 4 Nov. 1 Dec. 4 Jan. 5 Feb. 2 Mar.	July 1 Aug. 1 Sept. 6 Oct. 11 Nov. 12 Dec. 16 Jan. 19 Feb. 20 Mar. 6

* Interpolated.

TABLE 23.

OVA DIAMETERS.

No.	Month and Year.	Number of Fish.	Number of Ova measured.	Mean Ova Diameter.
	1950—			mm
1	March	5	250	0·614
2	April	24	1,200	0·537
3	May	12	600	0·553
4	June	13	650	0·576
5	July	15	750	0·577
6	August	65	3,250	0·639
7	September	35	1,750	0·633
8	October	1	50	0·608
9	November	65	3,250	0·654
10	December	15	750	0·710
	1951—			
11	January	5	250	0·933
12	February	10	500	1·108

Table 24.

Average Weight at Each Millimetre of Length for all Pilchards. January to December, 1952.

Males.

Standard Length. (cm)	Mean Weight. (gm)	Number of Fish.	Standard Length. (cm)	Mean Weight. (gm)	Number of Fish.	Standard Length. (cm)	Mean Weight. (gm)	Number of Fish.
12·4	24	1	16·6	—	—	20·8	122	49
12·5	—	—	16·7	60	1	20·9	123	51
12·6	26	1	16·8	63	2	21·0	126	79
12·7	—	—	16·9	63	1	21·1	129	84
12·8	—	—	17·0	—	—	21·2	129	67
12·9	—	—	17·1	60	1	21·3	138	80
13·0	28	2	17·2	67	1	21·4	134	81
13·1	29	2	17·3	80	1	21·5	134	86
13·2	31	1	17·4	73	2	21·6	138	92
13·3	33	1	17·5	79	7	21·7	138	97
13·4	33	4	17·6	76	6	21·8	139	88
13·5	32	5	17·7	78	8	21·9	141	113
13·6	33	2	17·8	85	5	22·0	145	143
13·7	—	—	17·9	79	11	22·1	145	99
13·8	—	—	18·0	82	15	22·2	146	118
13·9	—	—	18·1	85	14	22·3	148	92
14·0	37	2	18·2	84	16	22·4	150	85
14·1	37	2	18·3	83	23	22·5	150	82
14·2	—	—	18·4	87	23	22·6	155	78
14·3	—	—	18·5	88	25	22·7	155	76
14·4	—	—	18·6	86	20	22·8	161	66
14·5	40	2	18·7	88	30	22·9	162	73
14·6	—	—	18·8	91	38	23·0	163	64
14·7	—	—	18·9	93	19	23·1	161	38
14·8	—	—	19·0	92	45	23·2	166	35
14·9	—	—	19·1	95	40	23·3	166	46
15·0	—	—	19·2	96	50	23·4	167	25
15·1	—	—	19·3	98	63	23·5	169	33
15·2	—	—	19·4	99	59	23·6	171	14
15·3	—	—	19·5	100	62	23·7	174	20
15·4	—	—	19·6	102	55	23·8	184	11
15·5	—	—	19·7	104	64	23·9	187	14
15·6	—	—	19·8	106	72	24·0	180	9
15·7	—	—	19·9	108	56	24·1	183	10
15·8	—	—	20·0	107	81	24·2	185	5
15·9	—	—	20·1	112	53	24·3	197	4
16·0	55	1	20·2	112	61	24·4	201	3
16·1	—	—	20·3	115	63	24·5	177	2
16·2	—	—	20·4	116	45	24·6	—	—
16·3	—	—	20·5	118	60	24·7	190	2
16·4	—	—	20·6	119	57	24·8	173	1
16·5	62	2	20·7	121	58	24·9	207	2

TABLE 25.

AVERAGE WEIGHT AT EACH MILLIMETRE OF LENGTH FOR ALL PILCHARDS.
JANUARY TO DECEMBER, 1952.

FEMALES.

Standard Length. (cm)	Mean Weight. (gm)	Number of Fish.	Standard Length. (cm)	Mean Weight. (gm)	Number of Fish.	Standard Length. (cm)	Mean Weight. (gm)	Number of Fish.
10·9	17	1	16·5	—	—	21·1	130	56
12·0	—	—	16·6	65	1	21·2	131	58
12·1	—	—	16·7	—	—	21·3	133	50
12·2	23	1	16·8	58	2	21·4	133	54
12·3	26	2	16·9	63	3	21·5	138	80
12·4	—	—	17·0	—	—	21·6	138	66
12·5	25	2	17·1	70	2	21·7	141	73
12·6	—	—	17·2	82	1	21·8	141	91
12·7	27	1	17·3	76	7	21·9	142	96
12·8	37	1	17·4	77	2	22·0	146	119
12·9	—	—	17·5	74	6	22·1	150	111
13·0	27	1	17·6	81	3	22·2	149	129
13·1	—	—	17·7	75	8	22·3	151	136
13·2	—	—	17·8	73	3	22·4	152	127
13·3	32	3	17·9	77	7	22·5	153	121
13·4	32	2	18·0	84	7	22·6	155	127
13·5	33	2	18·1	87	4	22·7	157	126
13·6	—	—	18·2	82	9	22·8	158	138
13·7	35	1	18·3	87	12	22·9	160	114
13·8	34	1	18·4	86	9	23·0	163	137
13·9	35	1	18·5	90	20	23·1	165	95
14·0	36	4	18·6	89	28	23·2	166	110
14·1	39	1	18·7	88	26	23·3	168	99
14·2	—	—	18·8	95	30	23·4	172	88
14·3	—	—	18·9	94	35	23·5	173	95
14·4	—	—	19·0	92	26	23·6	179	79
14·5	—	—	19·1	94	26	23·7	178	74
14·6	39	1	19·2	95	36	23·8	174	70
14·7	—	—	19·3	99	52	23·9	181	57
14·8	—	—	19·4	100	42	24·0	182	64
14·9	41	1	19·5	100	46	24·1	185	53
15·0	—	—	19·6	102	43	24·2	183	45
15·1	—	—	19·7	105	48	24·3	192	32
15·2	—	—	19·8	106	61	24·4	196	19
15·3	—	—	19·9	104	53	24·5	192	27
15·4	—	—	20·0	108	74	24·6	191	19
15·5	—	—	20·1	112	47	24·7	195	10
15·6	—	—	20·2	112	79	24·8	191	9
15·7	46	2	20·3	118	72	24·9	191	9
15·8	—	—	20·4	117	62	25·0	209	10
15·9	—	—	20·5	118	51	25·1	208	8
16·0	60	2	20·6	122	62	25·2	209	4
16·1	—	—	20·7	121	63	25·3	233	4
16·2	—	—	20·8	125	59	25·4	210	5
16·3	—	—	20·9	128	51	25·5	225	2
16·4	—	—	21·0	129	61	25·7	241	1
						25·9	206	1

TABLE 26.—MEAN CONDITION FACTOR PER LENGTH GROUP FOR ALL FISH—1952.

Length Group.	January.		February.		March.		April.		May.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm										
10·5–10·9	—	—	—	—	—	—	—	—	—	—
12·0–12·4	—	—	—	—	—	—	(1) 0·759	—	—	—
12·5–12·9	—	—	—	—	—	—	—	—	—	(1) 0·707
13·0–13·4	—	—	—	—	—	—	—	—	—	—
13·5–13·9	—	—	—	—	—	—	—	—	(1) 0·691	—
14·0–14·4	—	—	—	—	—	—	—	—	—	—
14·5–14·9	—	—	—	—	—	—	—	—	—	—
15·0–15·4	—	—	—	—	—	—	—	—	—	—
15·5–15·9	—	—	—	—	—	—	—	—	—	—
16·0–16·4	—	—	—	—	—	—	—	(1) 0·818	—	—
16·5–16·9	—	—	—	—	(2) 0·800	(1) 0·762	(1) 0·846	(1) 0·704	—	—
17·0–17·4	—	(5) 0·980	(3) 0·846	(1) 0·917	—	(1) 0·707	—	—	—	—
17·5–17·9	(4) 0·955	(3) 1·001	(14) 0·901	(5) 0·774	(10) 0·824	(7) 0·797	—	(2) 0·828	(1) 0·776	—
18·0–18·4	(7) 0·965	(4) 0·938	(28) 0·866	(9) 0·906	(21) 0·832	(11) 0·829	(13) 0·903	(4) 0·903	(3) 0·781	—
18·5–18·9	(5) 0·919	(9) 0·972	(31) 0·877	(35) 0·905	(35) 0·827	(30) 0·828	(11) 0·884	(15) 0·878	(7) 0·781	(5) 0·811
19·0–19·4	(6) 0·949	(3) 0·992	(37) 0·881	(27) 0·887	(54) 0·838	(45) 0·830	(20) 0·890	(13) 0·855	(27) 0·777	(18) 0·806
19·5–19·9	(7) 0·958	(5) 0·922	(25) 0·888	(27) 0·897	(44) 0·839	(44) 0·850	(42) 0·862	(28) 0·876	(45) 0·804	(33) 0·799
20·0–20·4	(5) 0·897	(11) 0·925	(18) 0·873	(28) 0·902	(34) 0·845	(52) 0·841	(43) 0·867	(51) 0·875	(40) 0·788	(46) 0·802
20·5–20·9	(4) 0·892	(8) 0·951	(24) 0·879	(17) 0·923	(32) 0·844	(34) 0·864	(35) 0·856	(47) 0·875	(39) 0·815	(35) 0·816
21·0–21·4	(6) 0·882	(3) 0·902	(37) 0·854	(16) 0·890	(44) 0·841	(25) 0·859	(65) 0·849	(62) 0·874	(67) 0·811	(40) 0·826
21·5–21·9	(1) 0·751	(8) 0·945	(36) 0·834	(22) 0·865	(56) 0·831	(32) 0·842	(86) 0·853	(78) 0·860	(76) 0·798	(64) 0·816
22·0–22·4	(10) 0·918	(15) 0·890	(32) 0·850	(28) 0·840	(58) 0·819	(61) 0·857	(69) 0·849	(105) 0·846	(84) 0·788	(77) 0·818
22·5–22·9	(4) 0·821	(11) 0·903	(35) 0·829	(46) 0·837	(37) 0·833	(71) 0·841	(52) 0·827	(91) 0·834	(43) 0·795	(87) 0·795
23·0–23·4	(3) 0·881	(9) 0·875	(25) 0·837	(65) 0·848	(18) 0·809	(53) 0·829	(30) 0·845	(77) 0·834	(22) 0·775	(54) 0·782
23·5–23·9	(3) 0·883	(6) 0·851	(12) 0·834	(40) 0·871	(11) 0·822	(28) 0·814	(6) 0·794	(51) 0·837	(8) 0·756	(34) 0·789
24·0–24·4	—	(6) 0·872	(5) 0·785	(30) 0·849	(1) 0·720	(20) 0·823	(4) 0·834	(23) 0·830	(2) 0·787	(24) 0·763
24·5–24·9	—	(1) 0·961	(1) 0·787	(11) 0·795	(1) 0·755	(3) 0·840	(1) 0·787	(5) 0·831	(1) 0·786	(9) 0·763
25·0–25·4	—	(2) 0·827	—	(5) 0·816	—	(1) 0·786	—	(1) 0·796	—	(1) 0·664
25·5–25·9	—	—	—	(1) 0·750	—	—	—	(1) 0·884	—	—

Numbers in brackets indicate numbers of fish examined.

TABLE 26 (*continued*).—MEAN CONDITION FACTOR PER LENGTH GROUP FOR ALL FISH—1952.

Length Group.	June.		July.		August.		October.		November.		Mean.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm												
10·5–10·9	—	(1) 0·810	—	—	—	—	—	—	(1) 0·825	(2) 0·814	(1) 0·825	(3) 0·812
12·0–12·4	—	(3) 0·808	—	—	—	—	—	—	—	—	(1) 0·759	(3) 0·808
12·5–12·9	(1) 0·786	(3) 0·896	—	—	—	—	—	—	—	—	(1) 0·786	(4) 0·801
13·0–13·4	(10) 0·797	(6) 0·804	—	—	—	—	—	—	—	—	(10) 0·797	(6) 0·804
13·5–13·9	(6) 0·798	(5) 0·797	—	—	—	—	—	—	—	—	(7) 0·744	(5) 0·797
14·0–14·4	(4) 0·806	(5) 0·804	—	—	—	—	—	—	—	—	(4) 0·806	(5) 0·804
14·5–14·9	(1) 0·802	(3) 0·796	—	—	—	—	—	—	—	—	(1) 0·802	(3) 0·796
15·0–15·4	—	—	—	—	—	—	—	—	—	—	—	—
15·5–15·9	—	(1) 0·786	—	—	—	(1) 0·665	—	—	—	—	—	(2) 0·725
16·0–16·4	(1) 0·807	—	—	—	—	—	—	—	(1) 0·785	—	(2) 0·796	(1) 0·818
16·5–16·9	—	—	—	—	—	—	—	—	(1) 0·799	(3) 0·820	(4) 0·815	(5) 0·762
17·0–17·4	—	(1) 0·668	—	—	—	—	—	—	(3) 0·826	(4) 0·845	(6) 0·836	(12) 0·823
17·5–17·9	—	—	—	(2) 0·718	—	—	—	—	(9) 0·815	(7) 0·829	(44) 0·854	(26) 0·825
18·0–18·4	(2) 0·788	(2) 0·737	(6) 0·749	(1) 0·668	(2) 0·727	—	—	—	(10) 0·832	(8) 0·836	(92) 0·827	(39) 0·834
18·5–18·9	(10) 0·768	(7) 0·757	(19) 0·721	(20) 0·742	(4) 0·755	(4) 0·775	—	—	(11) 0·858	(13) 0·867	(133) 0·821	(138) 0·837
19·0–19·4	(25) 0·767	(23) 0·765	(47) 0·757	(25) 0·750	(13) 0·723	(6) 0·754	(4) 0·810	—	(20) 0·882	(19) 0·881	(253) 0·827	(179) 0·836
19·5–19·9	(44) 0·778	(34) 0·770	(49) 0·769	(45) 0·761	(16) 0·756	(19) 0·740	(6) 0·859	(2) 0·794	(30) 0·874	(18) 0·869	(308) 0·839	(255) 0·828
20·0–20·4	(49) 0·802	(42) 0·781	(55) 0·800	(54) 0·787	(25) 0·765	(19) 0·757	(3) 0·781	(3) 0·835	(30) 0·881	(22) 0·902	(302) 0·830	(328) 0·841
20·5–20·9	(40) 0·802	(38) 0·805	(50) 0·787	(51) 0·815	(27) 0·763	(18) 0·769	(1) 0·821	(3) 0·833	(22) 0·874	(29) 0·871	(274) 0·833	(280) 0·852
21·0–21·4	(40) 0·805	(33) 0·802	(57) 0·801	(42) 0·807	(35) 0·769	(21) 0·770	(4) 0·800	(2) 0·794	(34) 0·848	(31) 0·857	(389) 0·826	(275) 0·838
21·5–21·9	(54) 0·792	(58) 0·802	(75) 0·791	(64) 0·813	(60) 0·769	(40) 0·761	(3) 0·775	(7) 0·821	(31) 0·869	(29) 0·862	(478) 0·806	(402) 0·839
22·0–22·4	(65) 0·799	(94) 0·797	(96) 0·779	(117) 0·814	(73) 0·766	(78) 0·785	(1) 0·851	(1) 0·811	(44) 0·871	(41) 0·873	(532) 0·829	(620) 0·833
22·5–22·9	(37) 0·795	(75) 0·799	(89) 0·795	(118) 0·790	(53) 0·757	(86) 0·771	—	(4) 0·772	(27) 0·881	(30) 0·849	(391) 0·815	(619) 0·820
23·0–23·4	(24) 0·778	(59) 0·791	(40) 0·793	(88) 0·782	(32) 0·743	(81) 0·774	—	(2) 0·761	(18) 0·867	(32) 0·834	(212) 0·814	(520) 0·811
23·5–23·9	(9) 0·792	(39) 0·772	(12) 0·796	(65) 0·788	(12) 0·747	(65) 0·778	(1) 0·816	(1) 0·738	(10) 0·867	(31) 0·868	(84) 0·811	(360) 0·811
24·0–24·4	(5) 0·791	(21) 0·770	(5) 0·852	(36) 0·779	(7) 0·774	(37) 0·764	—	(2) 0·775	(1) 0·867	(14) 0·851	(30) 0·801	(213) 0·808
24·5–24·9	—	(14) 0·791	—	(12) 0·745	(2) 0·690	(11) 0·724	—	—	(1) 0·923	(7) 0·860	(7) 0·788	(73) 0·812
25·0–25·4	—	(3) 0·775	—	(8) 0·821	—	(3) 0·843	—	—	—	(5) 0·874	—	(33) 0·800
25·5–25·9	—	(1) 0·756	—	(2) 0·811	—	—	—	—	—	—	—	(5) 0·800

Numbers in brackets indicate numbers of fish examined.

Table 27.

Mean Condition Factor per Length Groups Related to Stages of Maturity.

Stages.	January.		February.		March.		April.		May.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm	(4)		(17)		(12)		(2)		(2)	
(1) M. 10·5–17·9.....	0·955	—	0·891	—	0·820	—	0·803	—	0·733	—
		(12)		(15)		(20)		(8)		(1)
(1) F. 10·5–18·4.....	—	0·971	—	0·863	—	0·808	—	0·849	—	0·707
	(11)		(68)		(89)		(31)		(34)	
(2) M. 18·5–19·4.....	0·935	—	0·879	—	0·834	—	0·888	—	0·778	—
		(8)		(54)		(89)		(41)		(51)
(2) F. 19·0–19·9.....	—	0·948	—	0·892	—	0·840	—	0·869	—	0·801
	(16)		(115)		(166)		(229)		(222)	
(3) M. 20·0–21·9.....	0·881	—	0·856	—	0·839	—	0·855	—	0·803	—
		(30)		(83)		(143)		(238)		(185)
(3) F. 20·0–21·9.....	—	0·935	—	0·894	—	0·850	—	0·870	—	0·815
	(20)		(110)		(126)		(162)		(160)	
(4) M. 22·0–25·9.....	0·888	—	0·835	—	0·821	—	0·838	—	0·786	—
		(50)		(226)		(237)		(358)		(286)
(4) F. 22·0–25·9	—	0·882	—	0·845	—	0·837	—	0·839	—	0·794

Stages.	June.		July.		August.		October.		November.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm	(23)								(15)	
(1) M. 10·5–17·9.....	0·799	—	—	—	—	—	—	—	0·815	—
		(30)		(3)		(1)				(24)
(1) F. 10·5–18·4.....	—	0·802	—	0·707	—	0·665	—	—	—	0·832
	(35)		(66)		(17)		(4)		(31)	
(2) M. 18·5–19·4.....	0·767	—	0·747	—	0·731	—	0·810	—	0·873	—
		(57)		(70)		(25)		(2)		(37)
(2) F. 19·0–19·9.....	—	0·768	—	0·757	—	0·743	—	0·794	—	0·875
	(183)		(237)		(147)		(11)		(117)	
(3) M. 20·0–21·9.....	0·800	—	0·795	—	0·767	—	0·790	—	0·867	—
		(171)		(211)		(98)		(15)		(111)
(3) F. 20·0–21·9.....	—	0·797	—	0·806	—	0·764	—	0·823	—	0·871
	(140)		(242)		(179)		(2)		(101)	
(4) M. 22·0–25·9.....	0·794	—	0·789	—	0·757	—	0·833	—	0·873	—
		(306)		(446)		(361)		(10)		(160)
(4) F. 22·0–25·9.....	—	0·791	—	0·793	—	0·774	—	0·771	—	0·857

Numbers in brackets indicate numbers of fish examined.

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TABLE 28.

MEAN CONDITION FACTOR PER LENGTH GROUP FOR ALL FISH—1953.

Length Group.	January.		February.		March.		April.		May.		June.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm												
10·5–10·9	—	—	—	—	—	—	—	—	—	—	—	—
12·0–12·4	—	—	—	—	—	—	—	—	—	—	—	—
12·5–12·9	—	—	—	—	—	—	—	—	—	—	—	—
13·0–13·4	—	—	—	—	—	—	—	—	—	—	—	—
13·5–13·9	—	—	—	—	—	—	—	—	—	(1) 0·762	—	—
14·0–14·4	—	—	—	—	—	—	—	—	(2) 0·770	(1) 0·812	—	(1) 0·700
14·5–14·9	—	—	—	—	—	—	—	—	(7) 0·782	(7) 0·775	—	—
15·0–15·4	—	—	—	—	—	—	—	—	(11) 0·761	(12) 0·773	(1) 0·729	—
15·5–15·9	—	—	—	—	—	—	(1) 0·826	—	(4) 0·749	(2) 0·746	—	(1) 0·844
16·0–16·4	—	—	—	—	—	—	(2) 0·798	(1) 0·815	(1) 0·731	(2) 0·766	(2) 0·783	(4) 0·803
16·5–16·9	—	—	—	—	—	—	—	—	—	(1) 0·831	—	(1) 0·820
17·0–17·4	—	—	—	—	—	—	—	—	—	—	—	(1) 0·719
17·5–17·9	—	—	—	—	—	—	—	—	—	—	—	(1) 0·800
18·0–18·4	—	—	—	—	—	—	—	—	—	—	(1) 0·788	(4) 0·714
18·5–18·9	—	—	(1) 0·896	(1) 0·902	—	—	(1) 0·839	—	(1) 0·814	(1) 0·863	(1) 0·771	(1) 0·774
19·0–19·4	(1) 0·927	—	(6) 0·958	(4) 1·005	(1) 0·819	(1) 0·989	—	—	(1) 0·848	—	(4) 0·793	(1) 0·753
19·5–19·9	(2) 0·916	(1) 0·925	(6) 0·939	(6) 0·913	(3) 0·937	(2) 0·938	(2) 0·815	—	(1) 0·809	(3) 0·871	(2) 0·802	(2) 0·791
20·0–20·4	(1) 0·974	(1) 0·878	(24) 0·965	(12) 0·968	(17) 0·901	(7) 0·901	(1) 0·894	(2) 0·794	(9) 0·821	(4) 0·826	(18) 0·813	(8) 0·837
20·5–20·9	(3) 0·825	(2) 0·910	(32) 0·934	(20) 0·965	(21) 0·953	(10) 0·970	(7) 0·856	(8) 0·873	(34) 0·845	(10) 0·845	(32) 0·824	(16) 0·808
21·0–21·4	(7) 0·873	(3) 0·906	(51) 0·945	(35) 0·966	(49) 0·950	(46) 0·948	(27) 0·870	(12) 0·919	(42) 0·855	(28) 0·859	(46) 0·811	(25) 0·816
21·5–21·9	(3) 0·829	(3) 0·859	(50) 0·926	(60) 0·972	(59) 0·963	(55) 0·971	(26) 0·906	(27) 0·932	(52) 0·834	(54) 0·846	(60) 0·817	(45) 0·813
22·0–22·4	(4) 0·860	(8) 0·860	(40) 0·921	(68) 0·937	(40) 0·925	(70) 0·943	(13) 0·850	(22) 0·891	(49) 0·816	(53) 0·855	(49) 0·796	(63) 0·815
22·5–22·9	(1) 0·868	(5) 0·881	(20) 0·946	(49) 0·941	(36) 0·942	(59) 0·945	(11) 0·871	(29) 0·879	(35) 0·807	(46) 0·847	(18) 0·750	(63) 0·797
23·0–23·4	(3) 0·888	(2) 0·855	(10) 0·953	(29) 0·923	(27) 0·914	(47) 0·952	(7) 0·864	(16) 0·855	(18) 0·809	(42) 0·824	(23) 0·797	(47) 0·781
23·5–23·9	—	—	(11) 0·943	(31) 0·917	(7) 0·938	(24) 0·948	(1) 0·943	(16) 0·843	(8) 0·775	(27) 0·831	(6) 0·776	(25) 0·801
24·0–24·4	—	—	(1) 0·906	(20) 0·915	(1) 0·915	(13) 0·913	—	(7) 0·853	(1) 0·777	(20) 0·824	(1) 0·744	(18) 0·759
24·5–24·9	—	—	(1) 0·752	(8) 0·942	—	(1) 1·024	—	(3) 0·855	—	(9) 0·826	(1) 0·799	(6) 0·836
25·0–25·4	—	—	(1) 0·962	(3) 0·923	—	(1) 0·870	—	(4) 0·874	—	—	—	(3) 0·826
25·5–25·9	—	—	—	—	—	(1) 0·862	—	—	—	(1) 0·766	—	—

TABLE 28 (*continued*).

MEAN CONDITION FACTOR PER LENGTH GROUP FOR ALL FISH—1953.

Length Group.	July.		August.		September.		October.		November.		December.		Mean.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M	F.
cm														
10·5–10·9.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12·0–12·4.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12·5–12·9.....	—	—	—	—	—	—	—	—	(2) 0·746	(1) 0·729	—	—	(2) 0·746	(1) 0·729
13·0–13·4.....	—	—	—	—	—	—	—	—	(3) 0·690	(3) 0·751	—	—	(3) 0·690	(3) 0·751
13·5–13·9.....	(1) 0·807	(2) 0·799	—	—	—	—	—	—	(4) 0·749	(1) 0·749	—	—	(5) 0·761	(4) 0·777
14·0–14·4.....	(2) 0·766	(3) 0·752	—	—	—	—	—	—	(5) 0·753	(3) 0·691	(1) 0·760	—	(10) 0·760	(1) 0·730
14·5–14·9.....	(8) 0·758	(2) 0·774	—	—	—	—	—	—	(2) 0·753	(2) 0·738	(2) 0·745	(6) 0·755	(19) 0·765	(17) 0·763
15·0–15·4.....	(3) 0·785	(2) 0·808	—	—	—	—	—	—	(1) 0·749	(1) 0·786	(10) 0·756	(9) 0·740	(26) 0·760	(24) 0·764
15·5–15·9.....	(1) 0·694	—	—	—	—	—	—	—	(1) 0·760	—	(16) 0·740	(14) 0·750	(23) 0·744	(17) 0·755
16·0–16·4.....	(2) 0·779	—	—	—	—	—	—	—	(1) 0·761	—	(7) 0·757	(14) 0·781	(15) 0·767	(21) 0·785
16·5–16·9.....	—	—	—	—	—	—	—	—	—	—	(12) 0·744	(5) 0·748	(12) 0·744	(7) 0·770
17·0–17·4.....	(1) 0·781	—	—	—	—	—	—	—	—	—	(10) 0·781	(9) 0·737	(11) 0·781	(10) 0·735
17·5–17·9.....	—	—	—	—	—	(1) 0·686	—	—	—	—	(9) 0·760	(7) 0·778	(9) 0·760	(9) 0·770
18·0–18·4.....	—	—	—	—	(1) 0·702	(2) 0·750	—	—	—	—	(17) 0·785	(14) 0·804	(19) 0·781	(20) 0·781
18·5–18·9.....	—	—	—	—	—	(3) 0·792	—	—	—	—	(7) 0·792	(12) 0·808	(11) 0·806	(18) 0·812
19·0–19·4.....	—	—	(1) 0·782	—	—	(3) 0·802	—	—	—	—	(5) 0·862	(17) 0·790	(19) 0·874	(26) 0·831
19·5–19·9.....	—	(2) 0·785	—	—	(1) 0·738	(3) 0·760	—	—	—	—	(3) 0·814	(1) 0·791	(20) 0·875	(20) 0·856
20·0–20·4.....	(4) 0·827	(1) 0·814	—	—	(9) 0·787	(2) 0·767	—	—	—	—	(4) 0·875	(2) 0·829	(87) 0·877	(39) 0·882
20·5–20·9.....	(13) 0·781	(2) 0·783	(11) 0·782	(4) 0·829	(29) 0·800	(9) 0·760	(4) 0·866	—	—	—	(3) 0·854	(2) 0·869	(189) 0·854	(83) 0·875
21·0–21·4.....	(30) 0·815	(11) 0·829	(39) 0·790	(14) 0·798	(56) 0·778	(22) 0·789	(4) 0·832	(3) 0·881	—	—	(18) 0·848	(6) 0·851	(369) 0·854	(205) 0·883
21·5–21·9.....	(38) 0·799	(45) 0·814	(38) 0·796	(29) 0·789	(34) 0·760	(35) 0·793	(4) 0·875	(6) 0·843	—	—	(6) 0·845	(10) 0·825	(370) 0·855	(369) 0·873
22·0–22·4.....	(45) 0·802	(67) 0·823	(32) 0·793	(53) 0·782	(34) 0·755	(51) 0·765	(7) 0·827	(7) 0·849	(1) 0·810	—	(8) 0·801	(8) 0·843	(322) 0·831	(470) 0·853
22·5–22·9.....	(21) 0·801	(63) 0·805	(34) 0·773	(52) 0·785	(21) 0·770	(43) 0·771	(7) 0·829	(8) 0·847	—	—	(1) 0·873	(5) 0·801	(205) 0·834	(422) 0·845
23·0–23·4.....	(12) 0·786	(63) 0·798	(24) 0·777	(47) 0·771	(12) 0·762	(33) 0·767	(6) 0·849	(7) 0·813	—	—	—	—	(142) 0·832	(333) 0·828
23·5–23·9.....	(4) 0·751	(41) 0·796	(8) 0·746	(31) 0·741	(2) 0·715	(25) 0·765	(1) 0·924	(7) 0·813	—	—	—	—	(48) 0·835	(227) 0·826
24·0–24·4.....	(2) 0·763	(23) 0·774	(5) 0·739	(20) 0·777	(1) 0·721	(13) 0·746	(2) 0·781	(6) 0·844	—	—	—	—	(14) 0·775	(140) 0·817
24·5–24·9.....	(1) 0·799	(8) 0·765	(2) 0·760	(5) 0·729	—	(3) 0·708	—	(2) 0·701	—	—	—	—	(5) 0·774	(45) 0·819
25·0–25·4.....	—	—	—	(1) 0·743	—	(2) 0·694	—	—	—	—	—	—	—	(14) 0·839
25·5–25·9.....	—	(2) 0·816	—	(1) 0·750	—	—	—	—	—	—	—	—	—	(5) 0·802

TABLE 29.

MEAN CONDITION FACTOR PER LENGTH GROUPS RELATED TO STAGES OF MATURITY.

Stages.	January.		February.		March.		April.		May.		June.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm												
(1) M. 10·5–17·9	—	—	—	—	—	—	(3) 0·807	—	(25) 0·764	—	(3) 0·765	—
(1) F. 10·5–18·4	—	—	—	—	—	—	—	(1) 0·815	—	(26) 0·774	—	(13) 0·765
(2) M. 18·5–19·4	(1) 0·927	—	(7) 0·949	—	(1) 0·819	—	(1) 0·839	—	(2) 0·831	—	(5) 0·789	—
(2) F. 19·0–19·9	—	(1) 0·925	—	(10) 0·950	—	(3) 0·955	—	—	—	(3) 0·871	—	(3) 0·778
(3) M. 20·0–21·9	(14) 0·861	—	(157) 0·940	—	(146) 0·950	—	(61) 0·884	—	(137) 0·842	—	(156) 0·816	—
(3) F. 20·0–21·9	—	(14) 0·861	—	(127) 0·969	—	(118) 0·958	—	(49) 0·914	—	(96) 0·849	—	(94) 0·815
(4) M. 22·0–25·9	(8) 0·871	—	(84) 0·932	—	(111) 0·929	—	(32) 0·863	—	(111) 0·809	—	(98) 0·786	—
(4) F. 22·0–25·9	—	(15) 0·866	—	(208) 0·931	—	(216) 0·944	—	(97) 0·869	—	(198) 0·838	—	(225) 0·797

Stages.	July.		August.		September.		October.		November.		December.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm												
(1) M. 10·5–17·9	(18) 0·766	—	—	—	—	—	—	—	(19) 0·742	—	(67) 0·754	—
(1) F. 10·5–18·4	—	(9) 0·780	—	—	—	(3) 0·729	—	—	—	(11) 0·733	—	(78) 0·765
(2) M. 18·5–19·4	—	—	(1) 0·782	—	—	—	—	—	—	—	(12) 0·821	—
(2) F. 19·0–19·9	—	(2) 0·785	—	—	—	(6) 0·781	—	—	—	—	—	(18) 0·790
(3) M. 20·0–21·9	(85) 0·803	—	(88) 0·791	—	(128) 0·779	—	(12) 0·858	—	—	—	(31) 0·851	—
(3) F. 20·0–21·9	—	(59) 0·816	—	(47) 0·795	—	(68) 0·787	—	(9) 0·856	—	—	—	(20) 0·838
(4) M. 22·0–25·9	(85) 0·796	—	(105) 0·776	—	(70) 0·759	—	(23) 0·833	—	(1) 0·810	—	(9) 0·809	—
(4) F. 22·0–25·9	—	(267) 0·803	—	(21) 0·772	—	(170) 0·764	—	(37) 0·826	—	—	—	(13) 0·827

Numbers in brackets indicate numbers of fish examined.

TABLE 30.

MEAN CONDITION FACTOR PER LENGTH GROUP FOR MALE AND FEMALE PILCHARDS (COMBINED) FOR 1952, 1953 AND 1952/53 COMBINED.

Length Groups.	1952. M. and F.	1953. M. and F.	1952/53. M. and F.
cm			
12·5–12·9	0·794	0·738	0·766
13·0–13·4	0·801	0·720	0·761
13·5–13·9	0·771	0·769	0·770
14·0–14·4	0·805	0·745	0·775
14·5–14·9	0·799	0·764	0·782
15·0–15·4	—	0·762	0·762
15·5–15·9	0·725	0·749	0·741
16·0–16·4	0·807	0·776	0·792
16·5–16·9	0·788	0·757	0·773
17·0–17·4	0·829	0·758	0·794
17·5–17·9	0·839	0·765	0·802
18·0–18·4	0·831	0·781	0·806
18·5–18·9	0·829	0·809	0·819
19·0–19·4	0·831	0·802	0·842
19·5–19·9	0·833	0·865	0·850
20·0–20·4	0·835	0·879	0·860
20·5–20·9	0·842	0·864	0·854
21·0–21·4	0·832	0·868	0·850
21·5–21·9	0·822	0·814	0·843
22·0–22·4	0·831	0·842	0·837
22·5–22·9	0·817	0·839	0·829
23·0–23·4	0·813	0·830	0·821
23·5–23·9	0·811	0·830	0·821
24·0–24·4	0·805	0·796	0·800
24·5–24·9	0·800	0·796	0·798
25·0–25·4	0·800	0·839	0·819
25·5–25·9	0·800	0·802	0·801

TABLE 31.

MEAN OIL YIELD FOR ST. HELENA BAY PILCHARDS FOR 1950 AND 1953.

Month.	Oil Yield in Gallons per Ton.	
	1950.	1953.
January	—	—
February	—	17·0
March	24·0	19·0
April	21·7	21·5
May	18·5	17·5
June	17·3	12·5
July	14·5	8·0
August	12·9	5·0
September	7·9	2·0
October	3·4	—
November	5·1	—
December	9·5	—

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Table 32.

Numbers of Male and Female Fish taken per Month in 1950.

Length Groups.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Totals.		Percentage Ratio.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm																												
17·5–17·9	—	—	—	—	—	—	1	4	1	3	1	1	3	7	4	—	1	—	—	—	2	—	—	—	13	15	46	54
18·0–18·4	—	—	—	—	—	1	—	3	13	8	2	3	19	10	13	8	4	3	1	—	5	1	—	—	57	36	61	39
18·5–18·9	—	—	—	—	—	—	3	6	18	25	8	10	18	13	15	12	2	4	1	—	18	2	—	—	83	72	54	46
19·0–19·4	—	—	—	—	2	2	7	7	34	38	19	20	25	34	29	29	13	3	2	1	24	10	—	—	155	144	52	48
19·5–19·9	—	—	—	—	1	—	12	4	29	33	22	36	20	30	32	29	7	6	6	3	30	32	2	1	161	174	48	52
20·0–20·4	—	—	—	—	1	—	12	8	42	33	41	32	27	28	40	22	11	26	6	12	27	39	2	2	209	202	51	49
20·5–20·9	—	—	—	—	1	1	22	11	38	69	47	58	23	20	35	29	28	22	15	22	25	41	11	3	245	276	47	53
21·0–21·4	—	—	—	—	1	1	23	16	49	35	45	41	28	28	43	34	16	12	13	18	26	34	7	2	251	221	53	47
21·5–21·9	—	—	—	—	2	—	29	13	61	49	68	52	29	35	48	33	32	19	16	26	34	39	—	3	319	269	54	46
22·0–22·4	—	—	—	—	2	3	72	41	91	90	103	93	47	51	87	74	45	39	25	24	67	44	12	4	551	463	54	46
22·5–22·9	—	—	—	—	6	3	70	16	95	118	99	131	55	53	94	125	49	55	32	28	90	93	19	12	609	634	49	51
23·0–23·4	—	—	—	—	2	6	51	97	71	129	50	149	21	74	69	148	35	85	12	37	59	132	22	15	392	872	31	69
23·5–23·9	—	—	—	—	2	2	30	71	28	118	30	100	8	41	37	125	17	69	5	37	45	108	6	19	208	690	23	77
24·0–24·4	—	—	—	—	1	5	10	54	6	49	7	52	8	27	6	63	12	46	3	26	18	63	4	12	75	397	16	84
24·5–24·9	—	—	—	—	1	3	—	29	1	21	1	23	1	12	2	39	1	27	2	16	6	35	2	7	17	212	7	93
25·0–25·4	—	—	—	—	—	1	4	11	—	17	—	6	—	5	1	13	—	6	1	4	—	15	—	5	6	83	7	93

Table 33.

Numbers of Male and Female Fish taken per Month in 1951.

Length Groups.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Totals.		Percentage Ratio.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm																												
17·5–17·9	—	—	—	—	—	1	—	—	—	—	—	—	9	12	—	1	—	—	—	—	4	9	—	2	13	25	34	66
18·0–18·4	—	—	2	1	2	4	—	—	—	1	1	—	7	10	—	1	—	—	—	—	5	6	1	1	18	24	43	57
18·5–18·9	—	—	2	1	—	2	—	—	1	5	1	1	4	14	2	1	—	—	—	1	6	3	2	6	18	34	35	65
19·0–19·4	—	—	—	1	2	2	—	1	6	5	2	2	10	16	1	1	—	—	—	—	5	5	6	4	32	37	46	54
19·5–19·9	—	—	2	1	4	—	1	1	7	5	4	1	13	11	3	4	3	1	1	—	4	3	1	3	43	30	59	41
20·0–20·4	—	2	5	1	3	3	2	2	19	13	13	7	28	25	5	8	1	2	3	—	10	9	4	—	93	72	56	44
20·5–20·9	—	3	4	2	5	4	14	4	50	18	48	21	58	48	31	18	3	1	1	1	19	15	4	3	237	138	63	37
21·0–21·4	1	3	10	8	5	12	29	22	88	81	66	51	88	83	69	57	9	7	3	1	39	23	9	6	416	354	54	46
21·5–21·9	3	3	9	5	22	9	39	40	69	76	59	73	99	90	60	67	13	11	3	1	48	42	7	16	431	433	50	50
22·0–22·4	5	2	20	11	18	22	59	39	82	71	64	72	92	86	72	64	13	18	3	1	54	43	8	12	490	441	53	47
22·5–22·9	10	12	21	11	51	42	91	71	60	90	58	73	105	103	64	93	14	10	12	2	43	47	14	11	543	565	49	51
23·0–23·4	8	11	22	26	46	74	64	94	37	98	33	71	63	118	47	98	15	12	4	—	35	64	9	10	383	676	36	64
23·5–23·9	2	16	4	29	19	74	21	80	35	80	16	49	25	97	24	90	5	21	—	3	23	39	5	19	179	597	23	77
24·0–24·4	—	4	1	21	12	58	11	45	16	42	2	39	10	67	6	62	4	15	—	2	5	40	—	9	67	404	14	86
24·5–24·9	1	3	2	9	—	11	—	33	2	17	—	13	1	26	1	29	1	7	—	—	3	15	2	4	13	167	7	93
25·0–25·4	—	1	—	7	—	8	—	3	—	8	—	4	—	6	—	9	—	3	—	—	—	7	—	—	—	56	—	100

Reprint from "Commerce & Industry", April, 1956

TABLE 34.

NUMBERS OF MALE AND FEMALE FISH TAKEN PER MONTH IN 1952.

Length Groups.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Totals.		Percentage Ratio.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm																												
17·5–17·9	4	3	14	5	10	7	—	3	1	—	—	—	—	2	—	—	—	—	—	—	9	7			38	27	58	42
18·0–18·4	7	4	28	11	21	11	13	4	3	—	2	2	6	1	2	—	—	—	—	—	10	8			92	41	69	31
18·5–18·9	5	9	31	35	34	31	11	15	7	5	10	7	19	20	4	4	—	—	—	—	11	13			132	139	49	51
19·0–19·4	6	3	37	26	57	45	20	14	27	18	25	23	48	25	14	6	—	—	5	—	20	19			259	179	59	41
19·5–19·9	7	5	25	27	46	45	23	28	45	23	44	35	49	45	15	19	—	—	7	2	30	18			291	247	54	46
20·0–20·4	6	12	18	28	34	54	44	51	41	45	49	43	55	54	25	19	—	—	3	4	30	22			305	332	48	52
20·5–20·9	4	7	23	17	33	35	36	48	39	35	40	39	50	51	27	18	—	—	1	3	22	28			275	281	49	51
21·0–21·4	6	3	36	18	45	25	65	62	68	40	40	35	57	42	35	21	—	—	5	2	33	31			390	279	58	42
21·5–21·9	1	12	38	22	56	32	86	78	74	62	54	58	75	64	60	40	—	—	3	8	32	29			479	405	54	46
22·0–22·4	10	15	38	30	58	61	69	105	88	81	65	92	96	107	73	78	—	—	1	2	44	41			542	612	47	53
22·5–22·9	4	11	36	48	37	72	52	92	43	83	37	71	89	108	63	86	—	—	—	4	17	31	—	—	378	606	38	62
23·0–23·4	3	9	26	65	17	54	29	78	22	61	25	54	40	88	32	81	—	—	—	3	18	32		—	212	525	29	71
23·5–23·9	3	7	13	47	13	35	17	51	8	32	9	38	10	67	12	65	—	—	2	1	9	31	—	—	96	374	20	80
24·0–24·4	—	6	5	29	1	20	4	23	2	24	5	21	5	36	2	37	—	—	—	3	1	14	—	—	25	213	11	89
24·5–24·9	—	1	1	10	1	3	1	5	1	9	—	14	—	12	1	12	—	—	—	—	1	7	—	—	6	73	8	92
25·0–25·4	—	1	—	5	—	1	—	5	—	2	—	3	—	8	—	3	—	—	—	—	—	5	—	—	—	33	—	100
25·5–25·9	—	—	—	1	—	—	—	1	—	—	—	2	—	2	—	—	—	—	—	—	—	—	—	—	—	6	—	100

Table 35.

Numbers of Male and Female Fish taken per Month in 1953.

Length Groups.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Totals.		Percentage Ratio.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm																												
18·0–18·4	3	7	—	—	—	—	—	—	—	—	1	4	—	—	—	—	1	2	—	—	—	—	15	13	20	26	43	57
18·5–18·9	5	8	1	1	—	—	1	—	—	1	1	1	—	—	—	—	—	3	—	—	—	—	6	11	14	25	36	64
19·0–19·4	2	4	5	4	1	1	—	—	1	—	4	1	—	—	1	—	—	3	—	—	—	—	5	15	19	28	40	60
19·5–19·9	3	4	6	6	3	2	4	—	1	3	2	2	—	2	—	—	1	3	—	—	—	—	3	1	23	23	50	50
20·0–20·4	1	1	24	12	17	7	1	3	9	4	18	8	4	1	—	—	9	2	—	—	—	—	4	4	87	42	67	33
20·5–20·9	3	2	32	20	21	10	7	8	33	10	32	16	13	2	11	4	29	9	4	—	—	—	2	2	187	83	69	31
21·0–21·4	7	3	51	35	50	46	27	12	42	28	46	25	30	11	39	13	56	22	4	3	—	—	12	5	364	203	64	36
21·5–21·9	3	3	50	50	60	55	26	27	53	54	60	45	38	45	38	29	34	35	4	6	—	1	6	9	372	359	51	49
22·0–22·4	4	8	40	68	40	70	13	22	49	53	49	63	45	67	32	53	34	51	7	7	1	—	9	8	323	470	41	59
22·5–22·9	1	5	20	59	36	59	11	29	35	46	18	6	21	63	34	52	21	43	7	7	—	1	1	3	205	373	35	65
23·0–23·4	3	2	11	29	27	47	7	16	18	42	24	47	12	63	24	47	12	33	6	8	—	—	—	—	144	334	30	70
23·5–23·9	—	—	11	31	7	24	1	16	8	37	6	24	4	41	8	31	2	25	1	7	1	—	—	1	49	237	17	83
24·0–24·4	—	—	1	20	1	13	—	8	1	20	1	18	1	23	5	20	1	13	2	5	—	—	—	—	13	140	8	92
24·5–24·9	—	—	1	8	—	1	—	3	—	9	—	6	2	8	2	5	—	3	—	2	—	—	—	—	5	45	10	90
25·0–25·4	—	—	—	3	—	1	—	4	—	—	—	2	—	—	—	1	—	2	—	—	—	—	—	—	—	13	—	100
25·5–25·9	—	—	—	1	—	1	—	—	—	1	—	—	—	2	—	1	—	—	—	—	—	—	—	—	—	6	—	100

Reprint from "Commerce & Industry", April, 1956

Table 36.

Numbers of Male and Female Fish taken per Month in 1954.

Length Groups.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Totals.		Percentage Ratio.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
cm																												
17·5–17·9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	2	—	—	—	—	1	2	33	67
18·0–18·4	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	1	—	—	—	—	—	3	1	75	25
18·5–18·9	1	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	2	1	—	—	—	—	4	3	57	43
19·0–19·4	2	—	—	—	—	1	2	—	—	—	—	—	2	1	—	—	—	—	3	1	—	—	—	1	9	4	69	31
19·5–19·9	4	—	5	2	4	2	3	3	—	—	—	—	3	2	2	—	2	1	4	2	—	—	1	2	28	14	67	33
20·0–20·4	4	—	5	5	5	5	7	12	1	2	2	2	12	12	3	2	5	4	8	5	2	—	9	14	63	63	50	50
20·5–20·9	5	8	1	3	12	13	9	3	13	12	6	10	15	17	4	4	8	4	16	10	11	5	12	17	112	106	51	49
21·0–21·4	19	11	12	8	15	15	27	11	50	20	24	15	30	23	16	10	16	8	25	15	11	10	3	24	248	170	59	41
21·5–21·9	29	18	21	8	33	18	53	15	68	46	57	36	59	31	18	15	20	17	49	30	12	18	4	26	423	278	60	40
22·0–22·4	24	39	24	29	43	30	61	65	112	90	61	67	69	89	19	24	22	23	56	47	9	18	5	14	505	535	49	51
22·5–22·9	15	42	12	24	17	34	35	68	55	114	40	84	34	100	7	25	11	16	34	65	4	17	2	12	266	631	30	70
23·0–23·4	9	48	5	19	7	25	17	55	29	101	20	60	16	101	3	17	2	12	7	47	5	17	—	3	120	505	19	81
23·5–23·9	1	10	—	12	3	11	3	36	7	57	8	39	7	44	2	6	2	1	3	31	—	8	—	1	36	256	12	88
24·0–24·4	2	5	—	1	—	5	1	11	1	29	1	13	—	20	—	—	—	1	1	7	—	2	—	—	6	94	6	94
24·5–24·9	—	3	—	—	—	2	—	4	1	7	—	—	—	11	—	—	—	2	—	7	—	—	—	—	1	36	3	97

TABLE 37.

MEAN RATIO OF MALE TO FEMALE PILCHARDS IN RELATION TO SEASON.
(Figures in brackets indicate percentages.)

Year.	Summer.		Autumn.		Winter.		Spring.	
	M.	F.	M.	F.	M.	F.	M.	F.
1951	221 (44)	279 (56)	992 (43)	1,317 (57)	1,364 (43)	1,892 (57)	411 (46)	490 (54)
1952	507 (44)	637 (56)	1,403 (48)	1,521 (52)	1,369 (44)	1,758 (56)	314 (46)	368 (54)
1953	288 (42)	394 (58)	611 (44)	793 (56)	626 (42),	852 (58)	237 (44)	296 (56)
1954	264 (42)	367 (58)	695 (42)	953 (58)	541 (39)	852 (61)	352 (44)	455 (56)
Mean Percentage	43	57	44	56	42	58	45	55

TABLE 38.

MEAN RATIO OF MALE TO FEMALE PILCHARDS IN RELATION TO LENGTH GROUP—1950–54.

Length Group.	M.	F.
cm	%	%
17·5–17·9	43	57
18·0–18·4	57	43
18·5–18·9	46	54
19·0–19·4	53	47
19·5–19·9	55	45
20·0–20·4	54	46
20·5–20·9	56	44
21·0–21·4	57	43
21·5–21·9	54	46
22·0–22·4	49	51
22·5–22·9	41	59
23·0–23·4	29	71
23·5–23·9	19	81
24·0–24·4	11	89
24·5–24·9	7	93
25·0–25·4	2	98
25·5–25·9	—	100

TABLE 39.

MEAN TEMPERATURES FOR 0–50 M, SURFACE AND AIR, FOR ST. HELENA BAY ONLY* FOR YEAR SEPTEMBER, 1950 TO AUGUST, 1951.

Month.	Mean Temperature 0–50 M.	Mean Temperature O M.	Air Temperature.
1950—	°C	°C	°C
September	12·4	13·9	14·7
October	12·8	14·0	15·1
November	11·1	13·6	14·5
December	11·7	14·2	15·1
1951—			
January	11·9	15·2	15·9
February	11·2	12·8	15·9
March	11·0	12·8	16·4
April	11·2	13·9	15·5
May	13·0	15·7	15·7
June	13·0	13·7	15·6
July	—	—	—
August	11·7	13·0	13·7

* Obtained from means of stations L, M, N, O and Q.

TABLE 40.

MEAN TEMPERATURES FOR 0–50 M, SURFACE AND AIR FOR ST. HELENA BAY ONLY* FOR YEAR 1953.

Month.	Mean Temperature, 0–50 M.	Mean Temperature, O M.	Air Temperature.
1953—	°C	°C	°C
January	10·9	14·2	17·5
February	10·2	13·2	15·9
March	12·3	16·3	17·6
April	14·2	14·7	15·2
May	11·0	14·1	14·8
June	10·8	13·0	13·5
July	13·2	13·1	13·6
August	12·5	12·9	13·6
September	12·6	14·1	14·4
October	9·5	10·9	12·7
November	10·2	12·2	14·0
December	12·1	13·4	13·9

* Obtained from means of stations L. M, N, O and Q.

TABLE 41.

MEAN TEMPERATURES FOR 0–50 M, SURFACE AND AIR FOR ST. HELENA BAY ONLY* FOR YEAR, 1954.

Month.	Mean Temperature, 0–50 M.	Mean Temperature, O M.	Air Temperature.
1954—	°C	°C	°C
January	10·6	13·3	14·9
February	10·8	14·8	17·2
March	11·1	16·2	18·2
April	11·5	13·8	14·7
May	13·2	14·1	13·9
June	12·8	13·8	17·9
July	13·3	13·7	11·9
August	13·1	13·7	14·0
September	11·7	12·9	13·7
October	11·2	13·2	14·3
November	10·1	10·9	14·8
December	10·7	14·2	15·9

* Obtained from means of stations L, M, N, O and Q.

TABLE 42.

NUMBERS OF OVA, MEAN TEMPERATURES FOR 0–50 M, SURFACE AND AIR FOR ROUTINE OFFSHORE STATIONS WHERE OVA WERE OBTAINED FOR YEAR, 1954.

Month.	Mean Temperature, 0–50 M.	Mean Temperature, O M.	Air Temperature.	Numbers of Ova.
1954—	°C	°C	°C	
January	15·4	16·8	17·3	5,585
February	13·7	17·6	18·6	39,750
March	15·4	17·0	20·7	11,072
April	13·8*	15·5*	16·0*	—
May	14·5	15·7	14·2	6
June	14·2	15·1	16·2	107
July	14·2*	14·5*	13·1*	—
August	14·0	14·3	13·3	5,350
September	14·2	14·8	14·1	17,716
October	14·2	15·0	15·8	4,363
November	14·0	15·4	16·7	7,290
December	14·9	16·5	14·2	282

* For all stations.

TABLE 43.

NUMBERS OF PILCHARD OVA IN EXCESS OF 1000 PER STATION (ALL STATIONS), AND ACCOMPANYING CONDITIONS OF TEMPERATURE AND SALINITY.

Year.	Month.	Station.	Number of Ova.	Temperatures.			Salinities.		
				O M.	10M.	20M.	O M.	10M.	20M.
1951	September....	P	3,200	13·88	12·24	12·29	34·56	34·60	34·63
	October.....	N	5,032	13·70	13·52	12·62	34·81	34·81	34·81
1952	February.....	L	1,586	17·49	15·40	11·70	34·79	34·81	34·85
	October.....	P	3,040	14·88	13·43	10·65	34·81	34·87	34·79
	November....	T	2,800	16·89	16·80	16·40	35·23	35·23	35·39
	November....	H	1,150	17·44	17·26	15·88	35·18	35·17	35·14
1953	February.....	H	1,100	15·07	14·92	14·41	35·05	35·03	34·99
	July.....	U	2,002	13·37	13·11	11·70	35·08	35·07	34·94
	July.....	V	1,602	16·09	15·87	15·65	35·32	35·30	35·28
	July.....	X	1,092	13·01	12·95	12·87	35·05	35·05	35·05
	July.....	R	1,402	13·80	13·67	13·73	35·12	35·12	35·14
	July.....	K	1,090	13·98	13·90	13·81	35·12	35·12	35·12
	August.....	W	1,951	14·98	14·91	14·84	35·26	35·26	35·26
	August.....	A	963*	14·55	14·53	14·51	35·28	35·28	35·28
	September....	P	7,450	13·89	13·73	12·88	34·83	34·83	34·83
1954	January.....	B	3,896	17·50	17·26	16·69	35·34	35·32	35·26
	February.....	V	35,220	21·20	19·86	16·48	35·43	35·35	35·12
	February.....	X	1,800	18·20	13·34	12·30	35·12	34·76	34·72
	February.....	H	1,200	15·17	13·59	11·72	34·81	34·76	34·70
	March.....	G	7,551	15·47	14·77	14·57	34·96	35·17	35·23
	March.....	T	3,898	18·65	17·46	16·38	35·39	35·39	35·34
	August.....	X	1,852	14·06	14·01	13·82	35·19	35·19	35·21
	August.....	R	4,839	14·07	14·05	13·81	35·14	35·17	35·19
	September....	G	10,595	15·21	15·03	14·95	35·36	35·36	35·36
	September....	E	2,352	14·71	14·69	14·69	35·32	35·32	35·32
	September....	N	3,480	13·16	12·70	12·51	34·78	34·78	34·81
	October.....	H	1,341	15·27	15·27	15·27	35·35	35·35	35·35
	October.....	D	1,646	15·70	15·59	15·18	35·34	35·34	35·30
	November....	W	1,799	15·83	15·75	15·64	35·19	35·19	35·19
	November....	T	1,898	15·41	15·39	15·38	35·16	35·16	35·16
	November....	B	954*	16·22	16·22	16·12	35·26	35·26	35·26
	MEAN.....			15·44	14·85	14·17	35·12	35·11	35·09
	RANGE.....			13·01 21·20	12·24 19·86	10·65 16·69	34·56 35·43	34·60 35·35	34·63 35·39

* This figure included as being close to 1,000.

TABLE 44.

MEAN TEMPERATURE FOR 0–50 METRES LAYER AND MEAN GONAD WEIGHTS—1951–54.

Month.	Mean Temperature in the 0–50 Metres Layer.				Mean.	Mean Gonad Weight. M. & F., 1951–54.
	1951.	1952.	1953.	1954.	1951–54.	
	°C	°C	°C	°C	°C	gm
January	11·9	12·0	10·9	10·6	11·4	11·6
February	11·2	11·8	10·2	10·8	11·0	10·6
March	11·0	11·6	12·3	11·1	11·5	7·6
April	11·2	11·3	14·2	11·5	12·1	2·7
May	13·0	11·8	11·0	13·2	12·3	2·0
June	13·0	11·8	10·8	12·8	12·1	3·1
July	—	11·0	13·2	13·3	12·5	5·1
August	11·7	12·2	12·5	13·1	12·4	6·6
September	12·3	13·6	12·6	11·7	12·6	6·2
October	11·9	11·9	9·5	11·2	11·1	8·4
November	10·7	12·9	10·2	10·1	11·0	10·6
December	10·6	11·7	12·1	10·7	11·3	9·4

Table 45.

Stations, 1954, at which Pilchard Ova were obtained.

Station.	Month.	Temperature °C			Salinity °/₀₀		
		0 m.	10 m.	20 m.	0 m.	10 m.	20 m.
E	January....	17·29	17·26	15·67	34·97	34·97	34·96
G		16·07	14·97	14·55	35·10	35·08	35·10
I		14·37	14·36	14·30	34·96	34·96	34·96
T		18·31	17·93	16·25	35·35	35·35	35·26
W		16·61	15·37	14·88	35·14	35·12	35·12
A		18·90	18·41	16·90	35·41	35·37	35·32
B		17·50	17·26	16·69	35·34	35·32	35·26
C		15·59	15·53	15·51	35·17	35·17	35·21
J	February..	18·35	16·01	14·72	34·94	34·90	34·88
A		20·62	19·57	18·05	35·32	35·25	35·14
C		20·54	18·99	15·63	35·35	35·19	35·26
F		20·61	20·61	17·47	35·41	35·41	35·16
I		18·00	17·61	15·13	35·08	35·03	34·96
P		15·27	14·08	9·48	34·70	34·67	34·67
Q		14·77	11·47	10·59	34·67	34·70	34·72
R		14·98	12·87	10·88	34·70	34·70	34·69
V		21·20	19·86	16·48	34·53	34·35	34·12
U		12·80	12·15	10·61	34·79	34·79	34·88
X		18·20	13·34	12·30	35·12	34·76	34·72
H		15·17	13·59	11·72	34·81	34·76	34·70
W	March.....	18·06	17·96	16·08	35·41	35·41	35·34
H		14·75	14·47	13·61	34·94	34·94	35·10
G		15·47	14·77	15·57	34·96	35·17	35·23
T		18·65	17·46	16·38	35·39	35·39	35·34
S		17·91	17·29	16·80	35·39	35·39	35·35
	April.....	—	—	—	—	—	—
U	May.....	16·81	16·80	16·68	35·21	35·21	35·21
M		14·64	14·59	14·43	34·76	34·76	34·78
U	June.....	15·26	15·21	14·31	35·16	35·16	35·16
V		15·33	15·33	15·33	35·16	35·16	35·16
W		16·08	16·08	16·08	35·25	35·25	35·25
G		16·17	16·17	16·17	35·30	35·30	35·30
Q		14·45	13·71	12·60	35·05	34·92	34·83
O		14·89	14·81	14·21	35·08	35·08	34·99
N		13·96	13·96	13·90	34·81	34·81	34·79
P		14·43	13·73	12·76	34·67	34·74	34·78
X	August....	14·06	14·01	13·82	35·19	35·19	35·21
R		14·07	14·05	13·81	35·14	35·17	35·19
S		14·85	14·57	14·48	35·34	35·32	35·32
B		14·97	14·96	14·95	35·39	35·39	35·39
K		13·97	13·97	13·97	35·21	35·21	35·21
L		14·02	14·02	14·02	35·14	35·14	35·14

TABLE 45 (*continued*).

STATIONS, 1954, AT WHICH PILCHARD OVA WERE OBTAINED.

Station.	Month.	Temperature °C			Salinity ‰		
		0 m.	10 m.	20 m.	0 m.	10 m.	20 m.
V	September.	14·99	15·02	14·99	35·35	35·35	35·35
W		15·19	15·19	15·17	35·36	35·36	35·36
X		15·09	15·09	15·09	35·35	35·35	35·35
H		15·03	14·97	14·95	35·36	35·36	35·36
G		15·21	15·03	14·95	35·36	35·35	35·35
T		15·10	14·89	14·83	35·36	35·35	35·35
S		14·80	14·80	14·80	35·35	35·35	35·35
A		14·88	14·88	14·88	35·35	35·35	35·35
B		14·95	14·93	14·53	35·35	35·35	35·35
C		15·25	15·25	15·23	35·35	35·35	35·35
D		15·08	15·08	15·08	35·35	35·35	35·35
E		14·71	14·69	14·69	35·32	35·32	35·32
I		14·85	14·86	14·82	35·35	35·35	35·35
F		14·77	14·77	14·75	35·35	35·35	35·35
L		13·71	13·40	13·22	34·97	34·97	34·97
M		12·26	11·69	11·36	34·79	34·79	34·81
N		13·16	12·70	12·51	34·78	34·78	34·81
U	October...	14·35	14·32	14·23	35·19	35·17	35·19
X		14·07	14·07	14·06	35·14	35·14	35·14
R		14·39	14·39	14·39	35·19	35·19	35·19
H		15·27	15·27	15·23	35·35	35·35	35·35
G		15·59	15·56	15·55	35·39	35·39	35·39
B		15·74	15·73	15·71	35·34	35·34	35·34
D		15·70	15·59	15·18	35·34	35·34	35·30
E		15·64	15·59	15·29	35·34	35·34	35·34
F		15·33	15·33	15·33	35·30	35·30	35·30
I		14·46	14·41	14·35	35·12	35·12	35·12
O		14·03	13·58	13·58	34·88	34·94	34·97
K		14·81	13·65	13·10	35·14	35·05	35·19
L		14·09	13·46	13·30	34·99	34·99	34·99
V	November.	15·68	15·53	13·04	35·19	35·19	35·16
W		15·83	15·75	15·64	35·19	35·19	35·19
X		14·87	14·71	11·08	34·79	34·79	34·87
H		15·08	15·08	15·02	35·14	35·14	35·14
E		14·13	14·05	13·55	34·97	34·97	34·96
G		15·27	15·25	14·78	35·23	35·23	35·19
T		15·41	15·39	15·38	35·16	35·16	35·16
B		16·22	16·22	16·12	35·26	35·26	35·26
I		15·42	15·42	15·37	35·25	35·25	35·25
K		15·32	14·92	13·98	35·03	35·03	35·03
X	December..	15·98	15·47	14·78	35·10	35·08	35·05
R		15·51	14·37	14·19	35·03	35·03	35·03
S		18·40	18·30	17·59	35·39	35·39	35·34
C		16·67	16·67	16·67	35·25	35·25	35·25
D		15·89	15·74	14·41	34·92	34·92	35·05
F		18·11	18·11	17·79	35·41	35·41	35·39
J		14·95	14·05	13·12	34·87	35·31	35·14

TABLE 46.

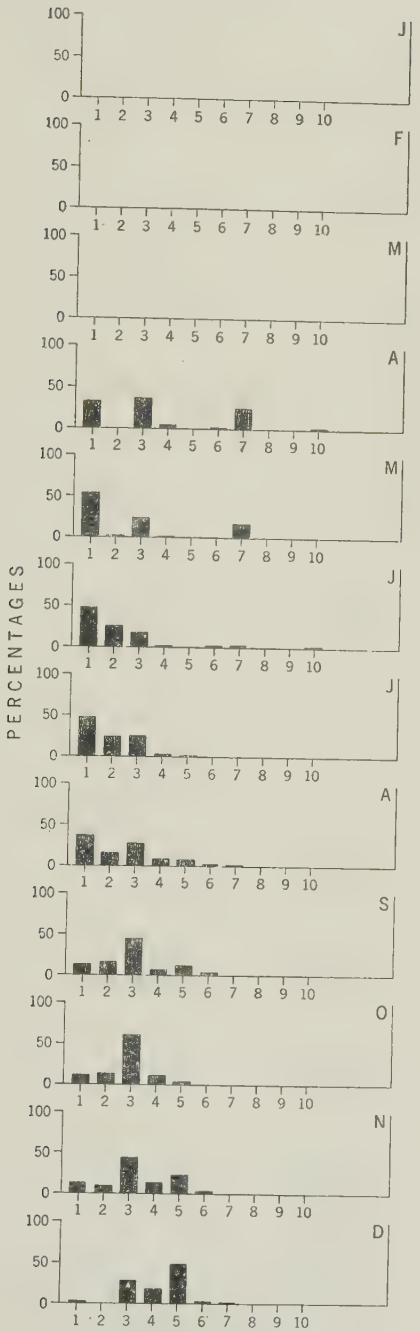
NUMBERS OF PILCHARD OVA FROM ALL STATIONS—1950–54.

Month.	1950.	1951.	1952.	1953.	1954.	Totals.
January		40	205	932	5,585	6,762
February		2,033	2,417	1,808	39,750	46,008
March		—	502	661	11,072	12,235
April	—	98	3	—	—	101
May	—	13	—	—	6	19
June	—	128	—	596	107	831
July	—	9	—	10,109	—	10,118
August	596	668	—	3,938	5,358	10,560
September	2,001	3,792	3,251	8,515	18,062	35,621
October	1,394	5,160	6,023	2,309	5,278	20,164
November	14	780	4,848	2	7,290	12,934
December	110	3	1,298	1,287	282	2,980
TOTAL	4,115	12,724	18,547	30,157	92,790	

♂ FISH

PLATE 1

1950



Percentages of male pilchards in each stage of maturity in 1950

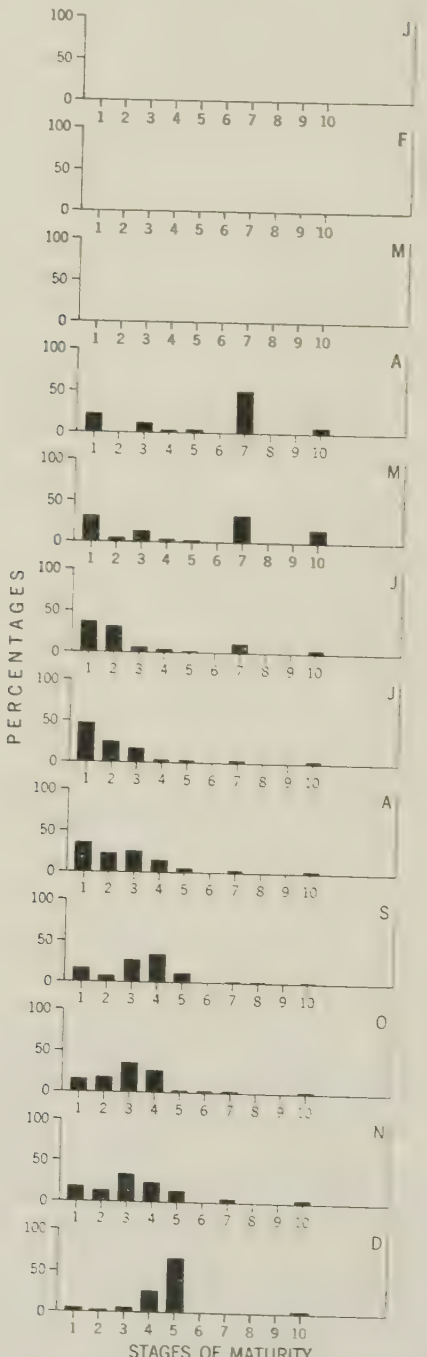
Trigsurvey, 1956.

Government Printer, 1956

♀ FISH

PLATE 2

1950



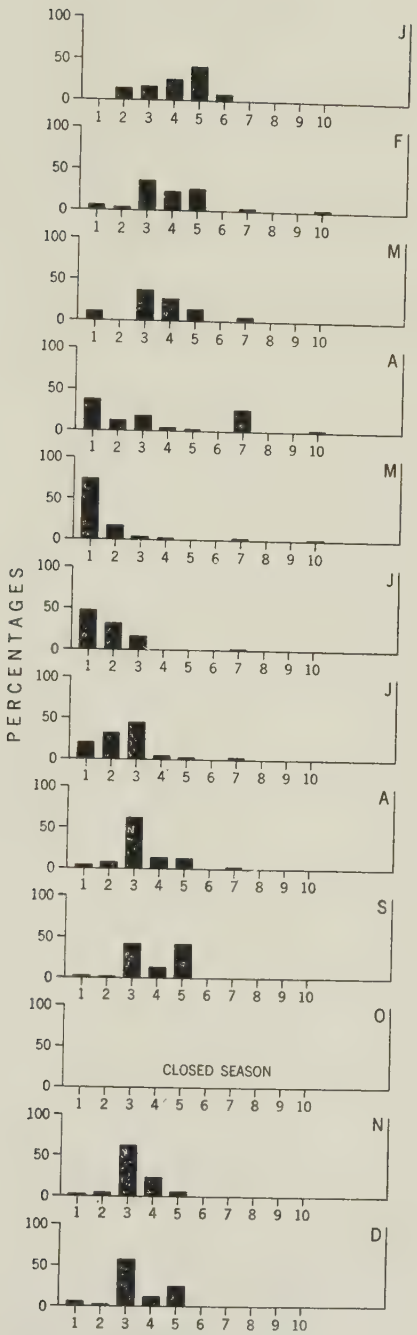
Percentages of female pilchards in each stage of maturity in 1950

Government Printer, 1956

♂ FISH

PLATE 3

1951



Percentages of male pilchards in each stage of maturity in 1951

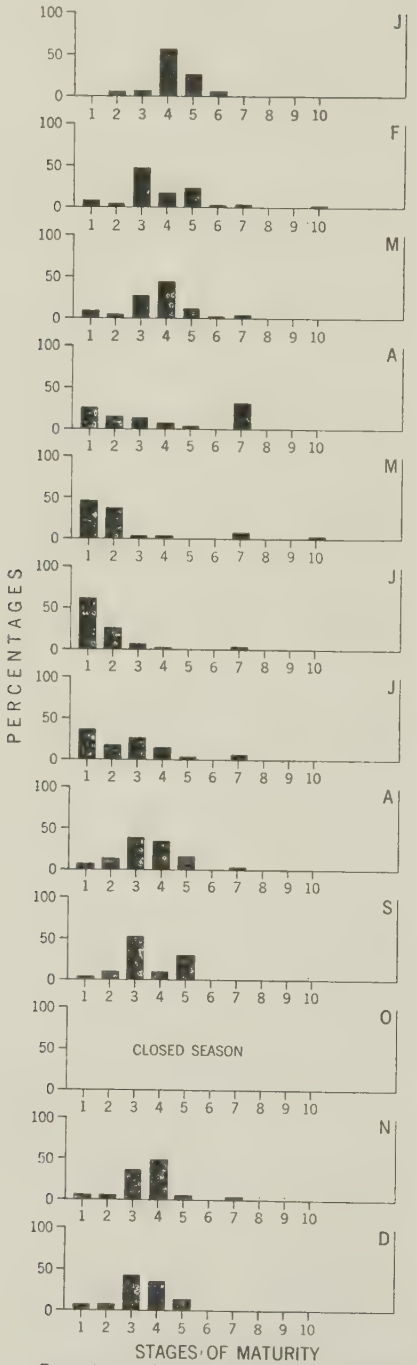
Trigsurvey, 1956.

Government Printer, 1956.

♀ FISH

PLATE 4

1951



Percentages of female pilchards in each stage of maturity in 1951

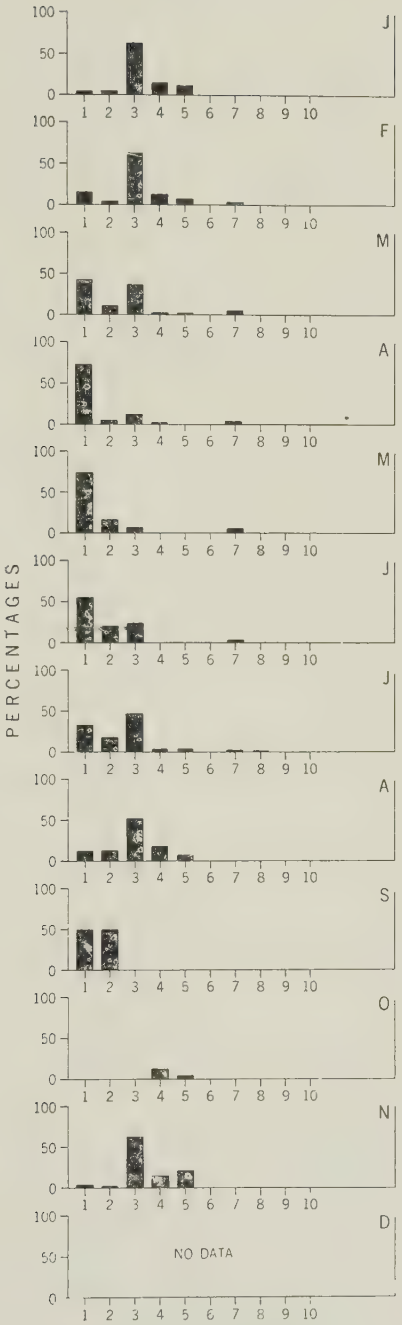
Trigsurvey, 1956.

Government Printer, 1956.

♂ FISH

PLATE 5

1952



Percentages of male pilchards in each stage of maturity in 1952

Irigsurvey 1956

Government Printer, 1956

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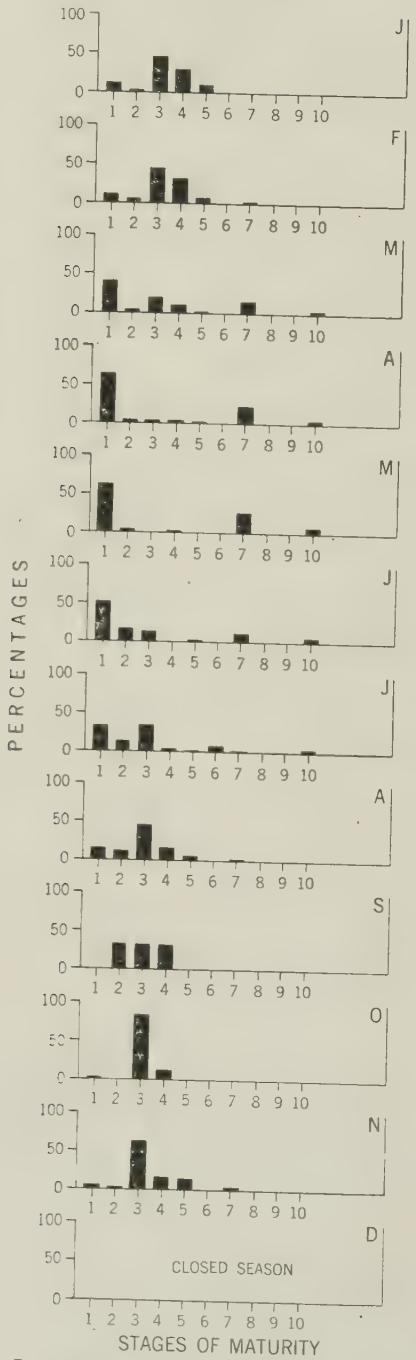
PLATE 6

1952



Percentages of female pilchards in each stage of maturity in 1952

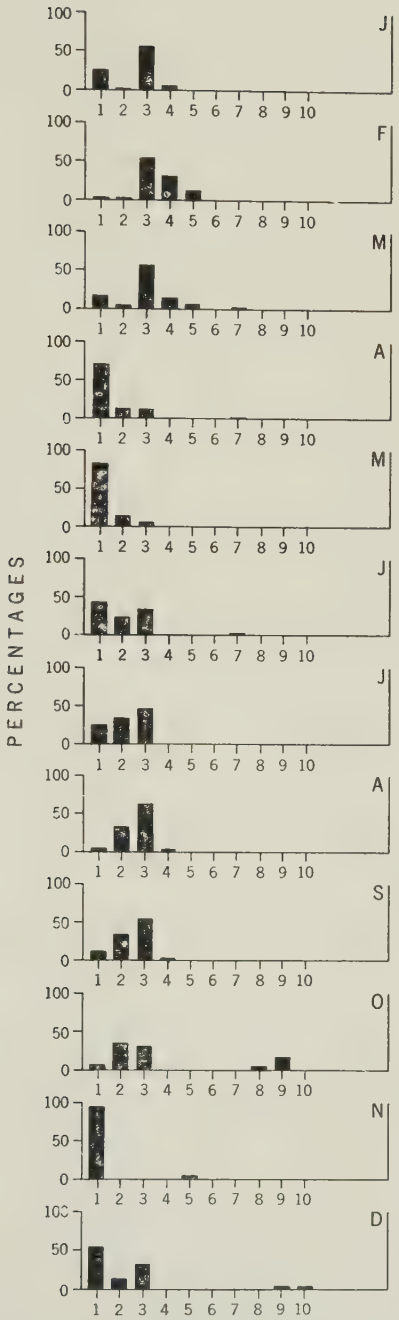
Engraved 1956

Government Printer 1956

♂ FISH

PLATE 7

1953



Percentages of male pilchards in each stage of maturity in 1953

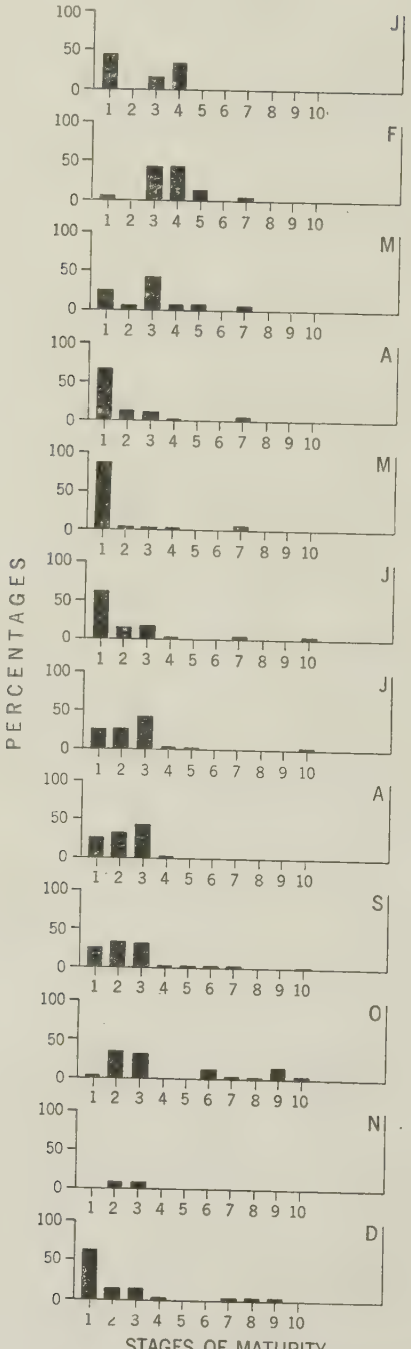
Trigsurvey, 1956.

Government Printer, 1956.

♀ FISH

PLATE 8

1953



Percentages of female pilchards in each stage of maturity in 1953

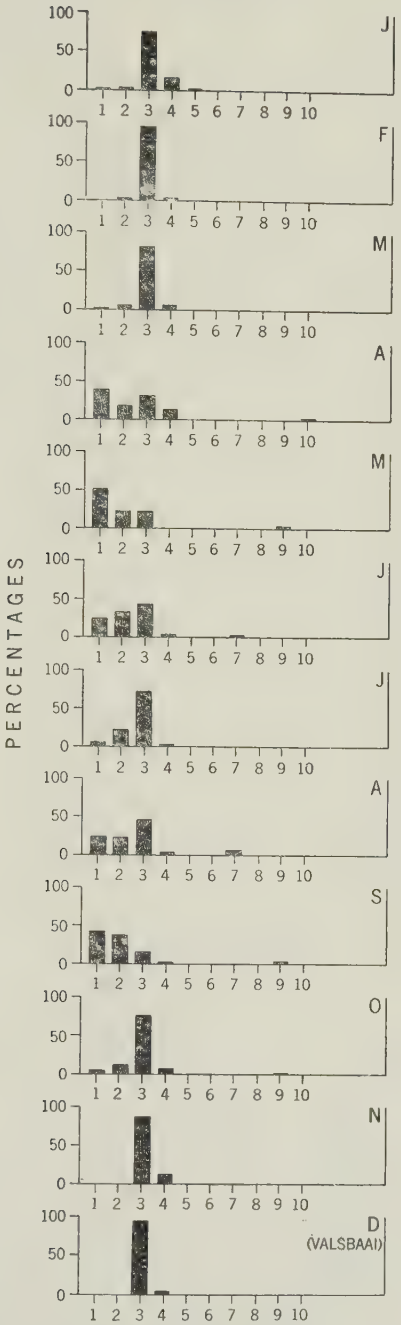
Trigsurvey, 1956.

Government Printer, 1956.

♂ FISH

PLATE 9

1954



Percentages of male pilchards in each stage of maturity in 1954

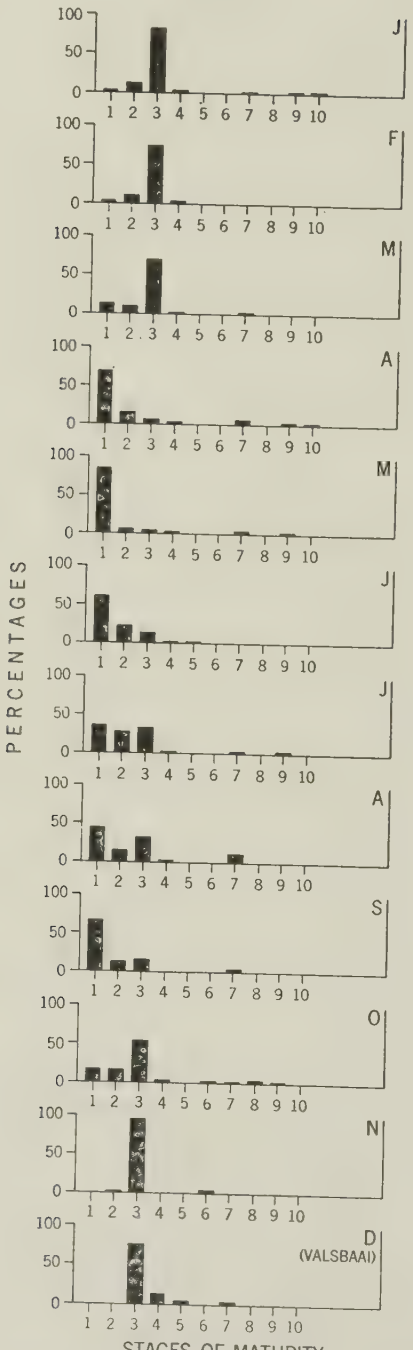
Trigsurvey, 1956.

Government Printer, 1956

♀ FISH

PLATE 10

1954



Percentages of female pilchards in each stage of maturity in 1954

Trigsurvey, 1956.

Government Printer 1956

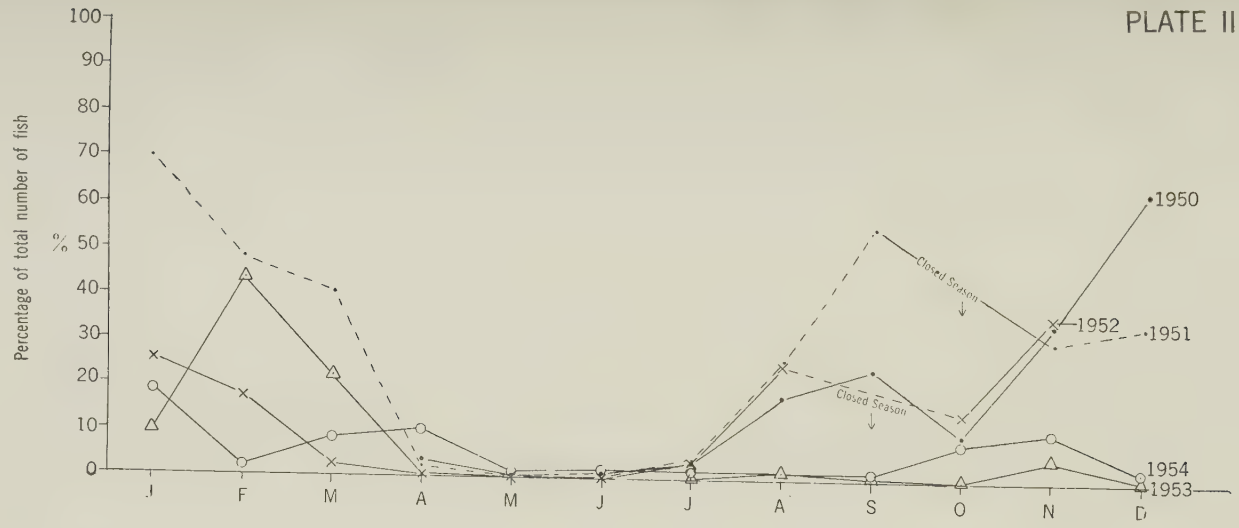


FIG. 1 PERCENTAGES OF MALE PILCHARD GONADS IN STAGES 4, 5 AND 6, 1950-1954.

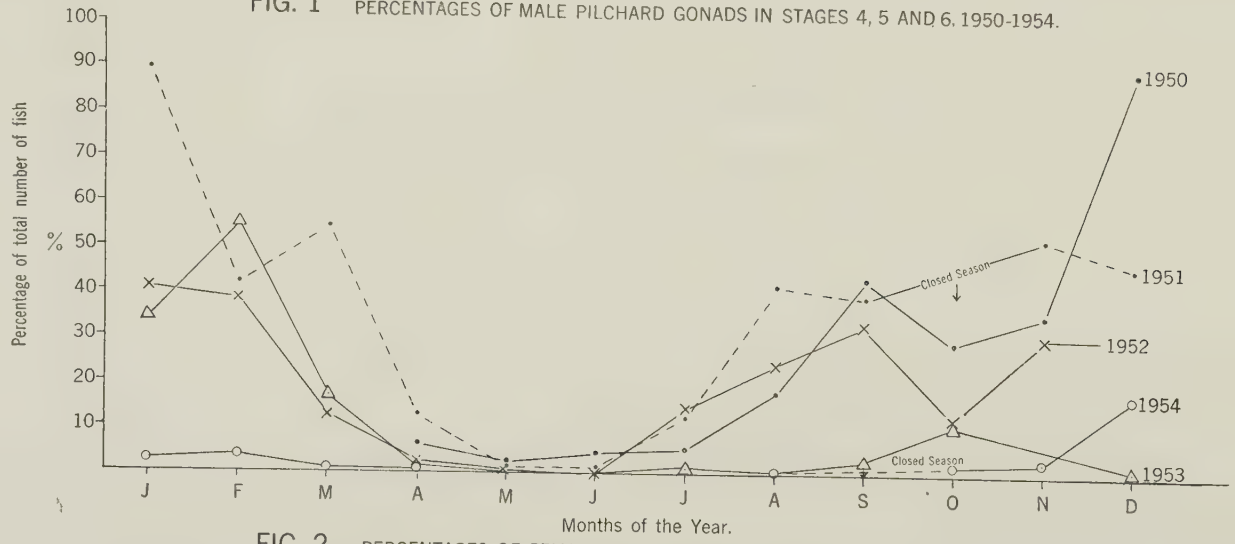


FIG. 2 PERCENTAGES OF FEMALE PILCHARD GONADS IN STAGES 4, 5 AND 6, 1950-1954.

Trigsurvey, 1956

Government Printer, 1956.

Reprint from "Commerce & Industry", April, 1956

PLATE 12

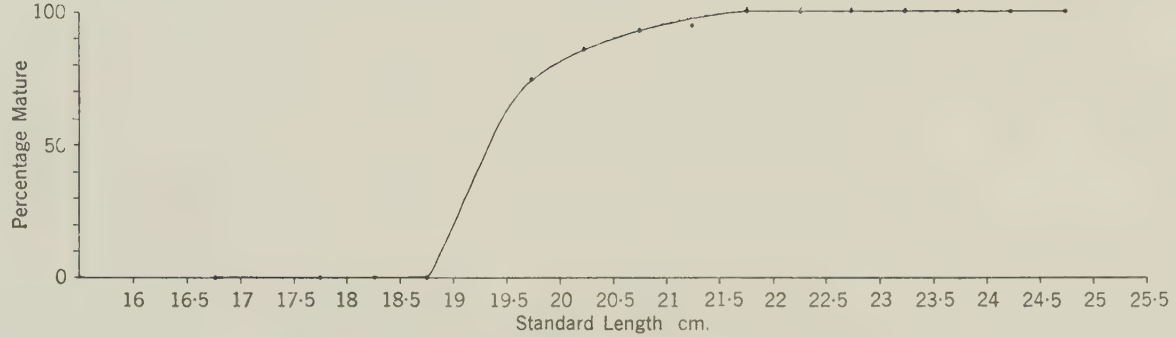


FIG. 1 SIZE AT FIRST MATURITY OF MALE PILCHARDS FOR 1950-51
(January, February, December only)

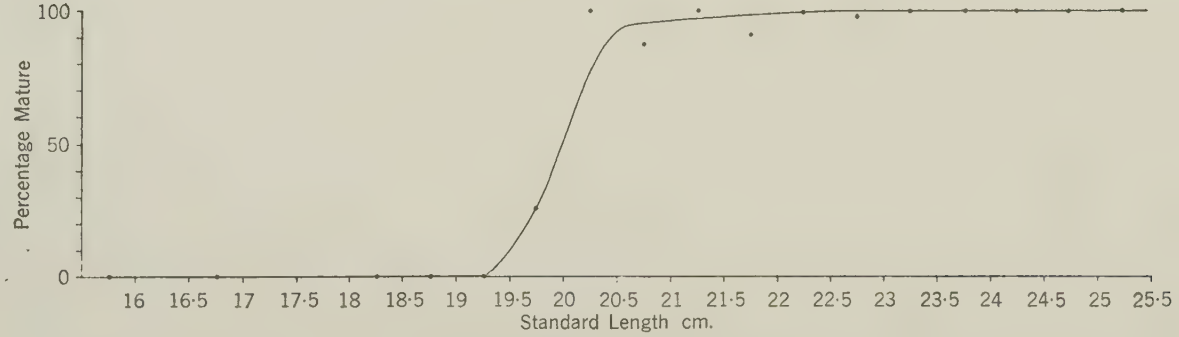


FIG. 2 SIZE AT FIRST MATURITY OF FEMALE PILCHARDS FOR 1950-51
(January, February, December only)

Trigsurvey, 1956.

Government Printer, 1956.

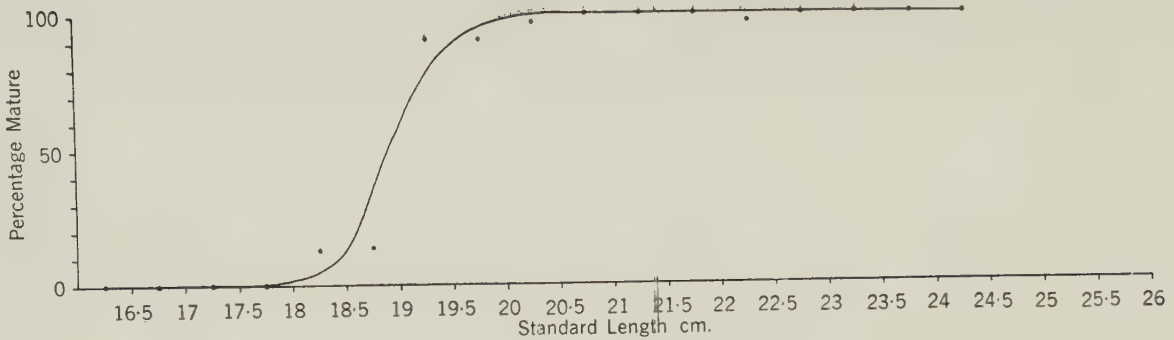


FIG. 3 SIZE AT FIRST MATURITY OF MALE PILCHARDS 1953
(January, February, October, November, December only)

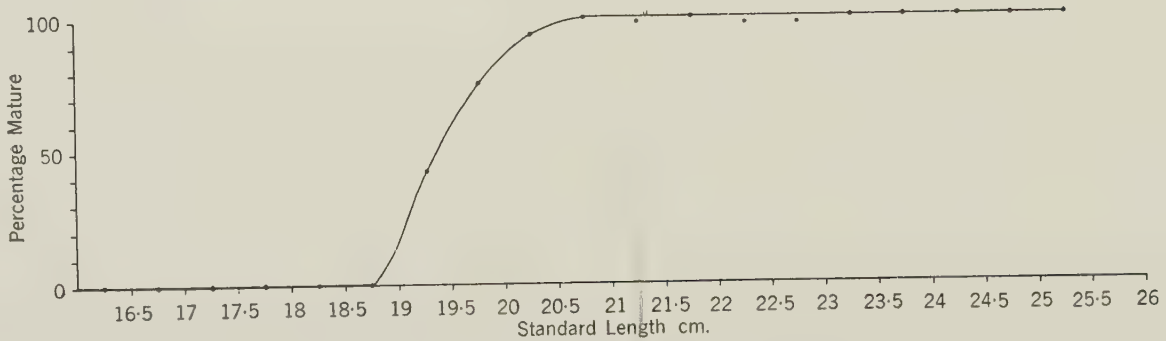


FIG. 4 SIZE AT FIRST MATURITY OF FEMALE PILCHARDS 1953
(January, February, October, November, December only)

Trigsurvey, 1956.

Government Printer, 1956.

Reprint from "Commerce & Industry", April, 1956

PLATE 13

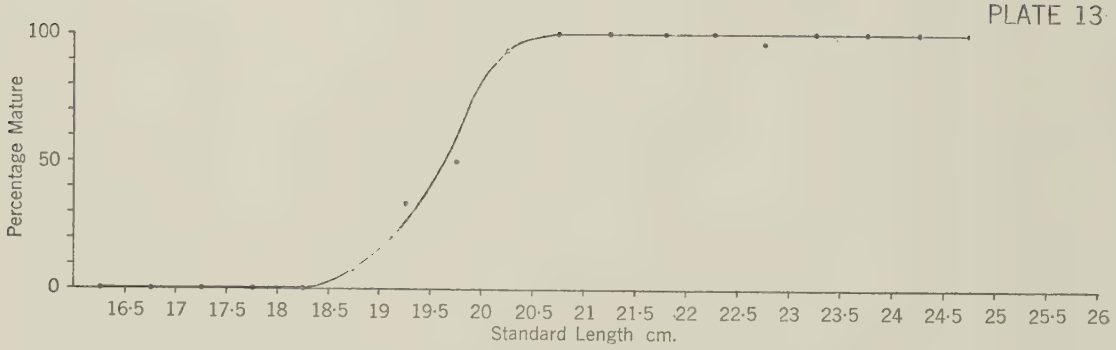


FIG. 1 SIZE AT FIRST MATURITY OF MALE PILCHARDS FOR 1952, EXCLUDING STAGE *a* FISH
(January, February, September, October, November only)

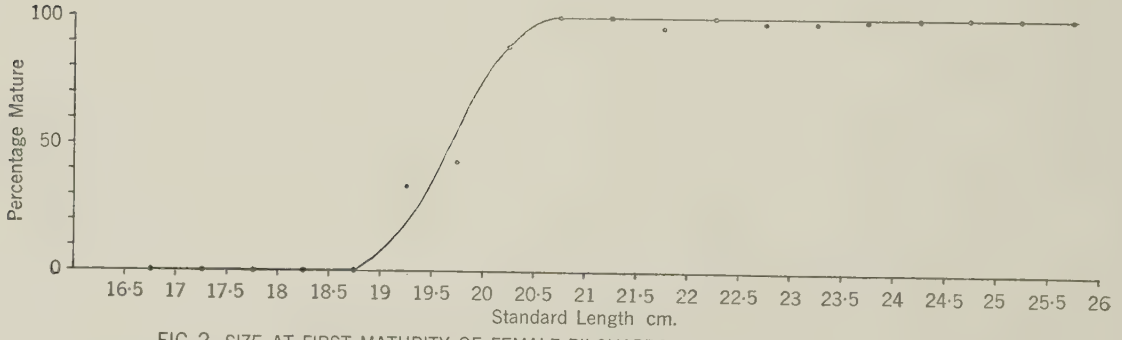
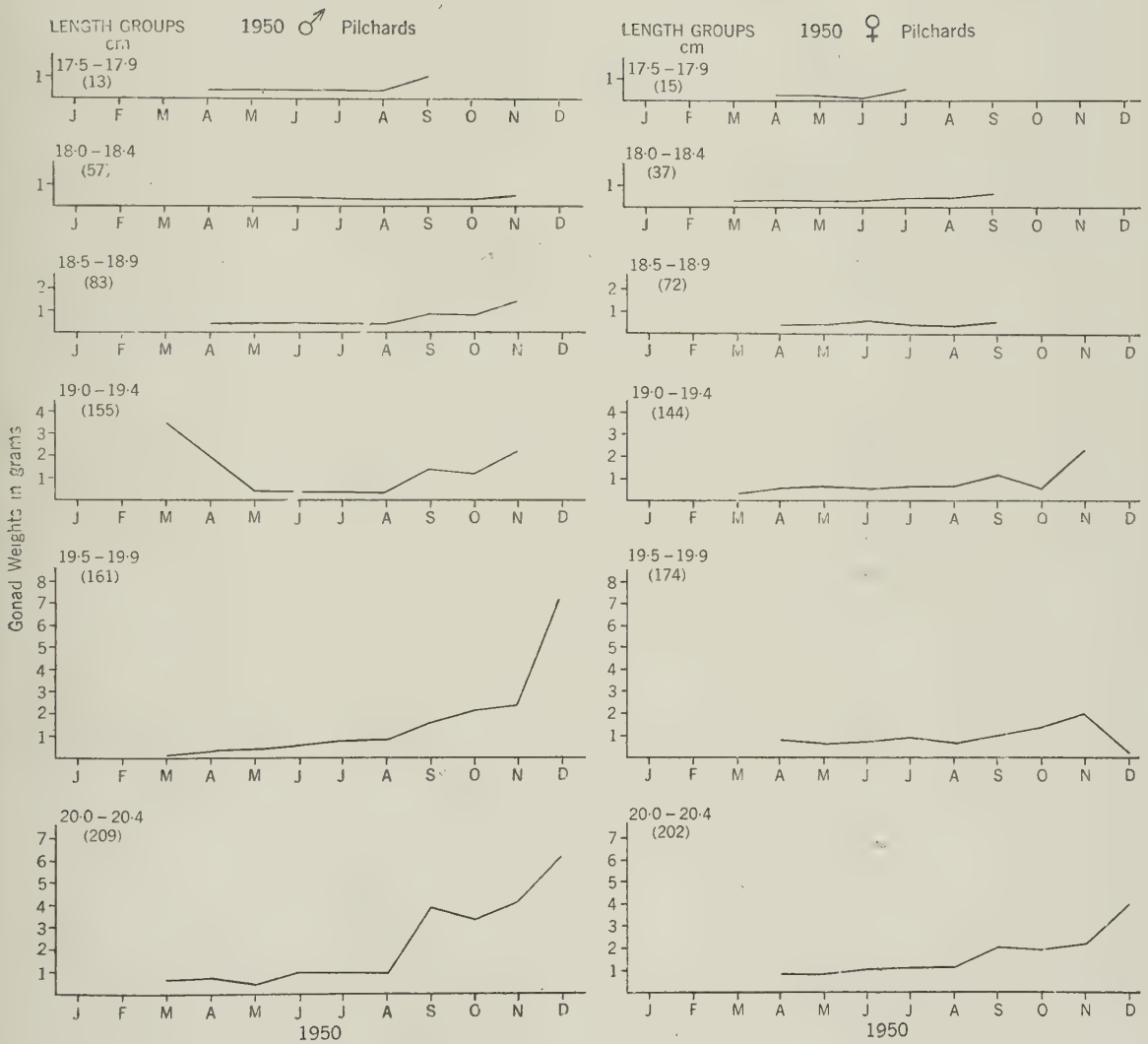


FIG. 2 SIZE AT FIRST MATURITY OF FEMALE PILCHARDS FOR 1952, EXCLUDING STAGE *a* FISH
(January, February, September, October, November only)

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 14

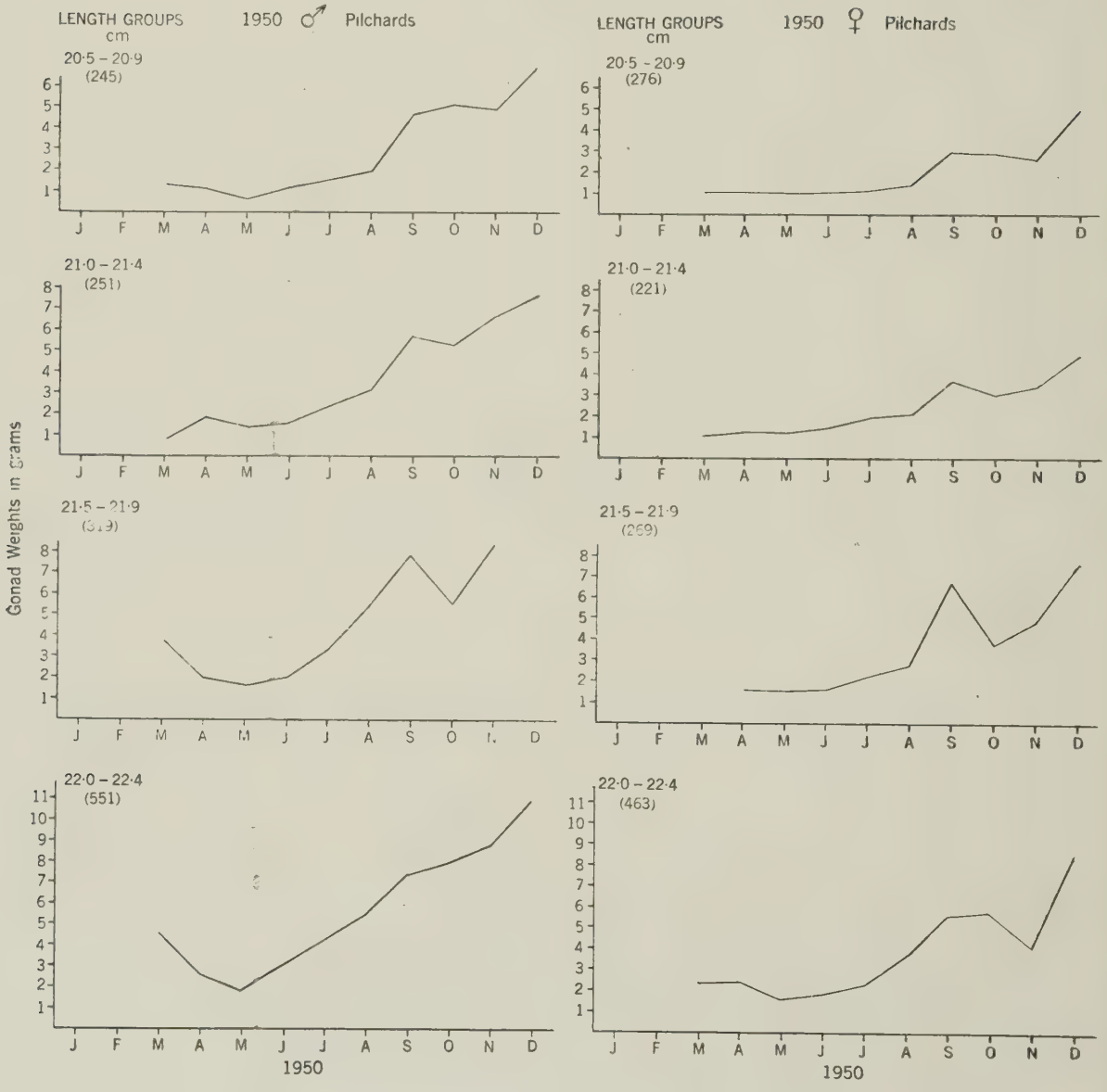


GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1950

N.B. Figures in brackets indicate numbers of fish examined

Trigsurvey, 1956. Government Printer, 1956.

PLATE 14



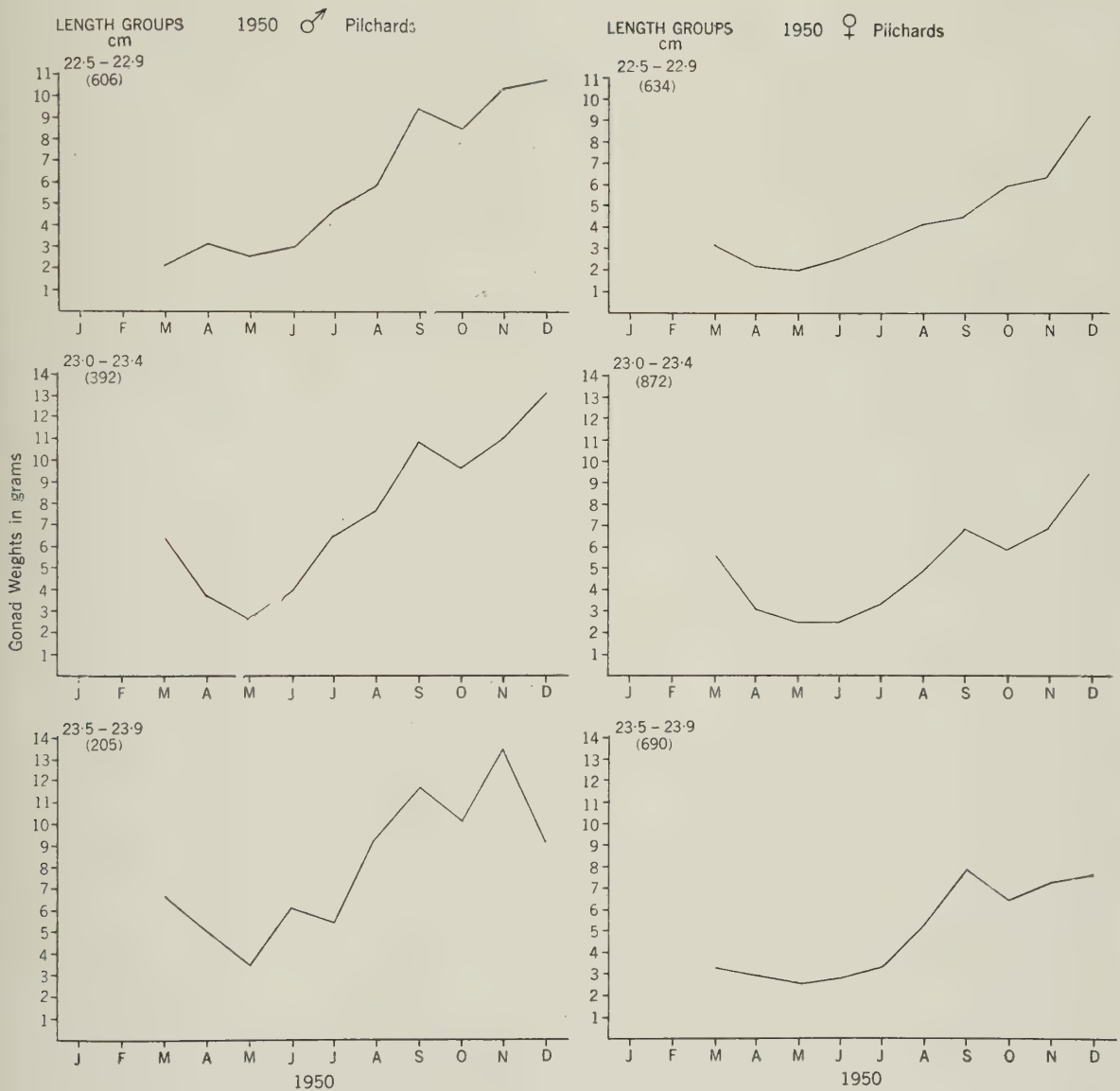
GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1950

N.B. Figures in brackets indicate numbers of fish examined

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 14


LENGTH GROUPS cm
1950 ♂ Pilchards
22·5 – 22·9 (606)
23·0 – 23·4 (392)
23·5 – 23·9 (205)
LENGTH GROUPS cm
1950 ♀ Pilchards
22·5 – 22·9 (634)
23·0 – 23·4 (872)
23·5 – 23·9 (690)
Gonad Weights in grams
J F M A M J J A S O N D
1950

GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1950

N.B. Figures in brackets indicate numbers of fish examined

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 14

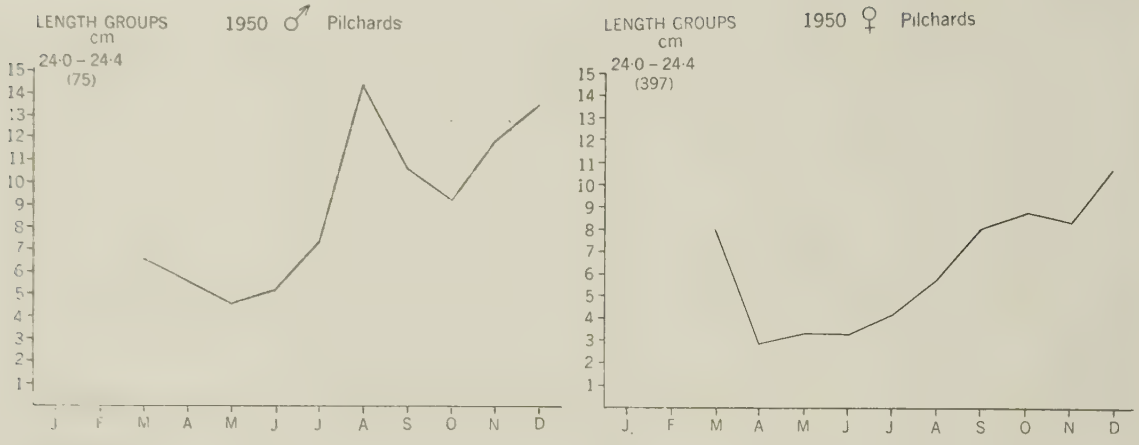
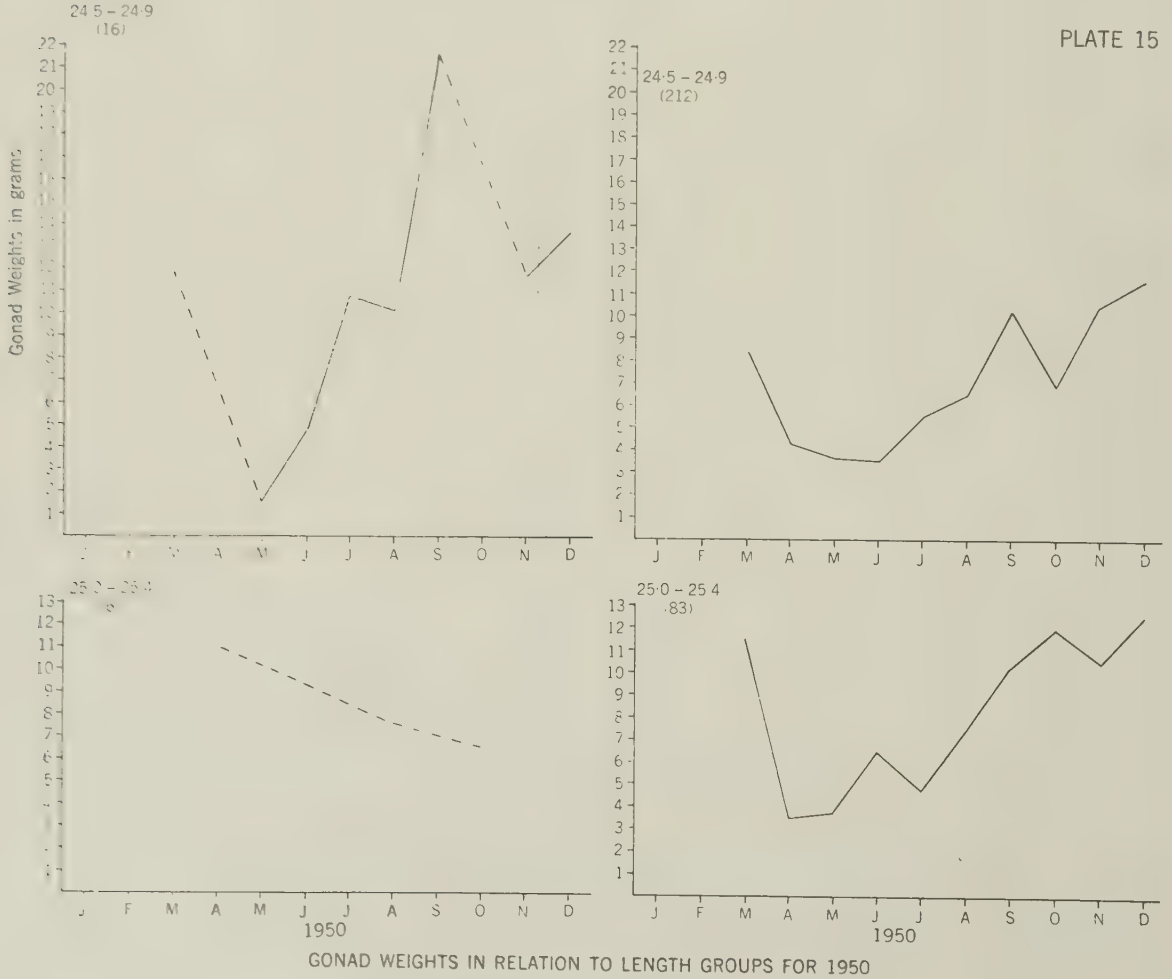


PLATE 15



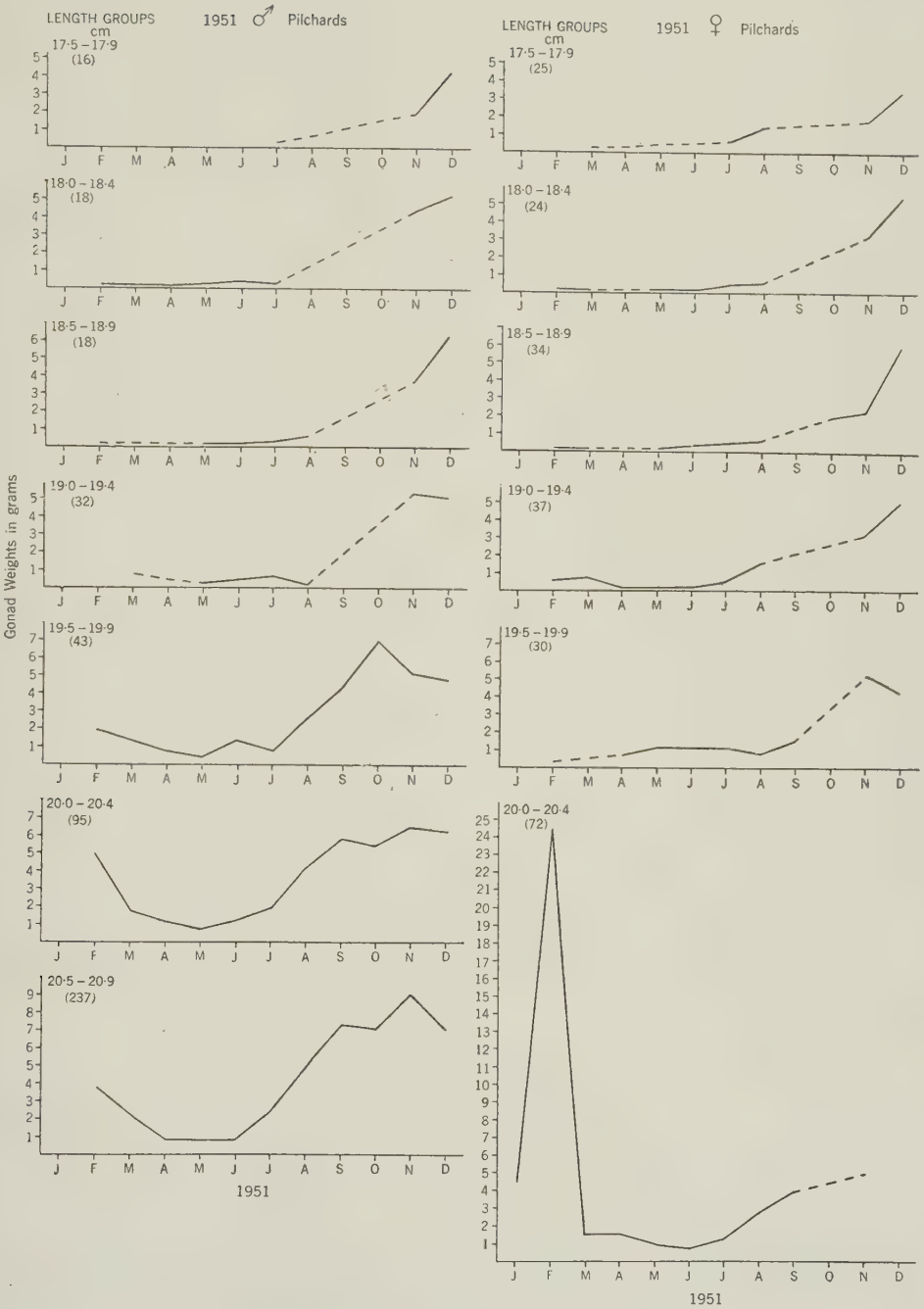
GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1950

N.B. 1 Figures in brackets indicate numbers of fish examined
2 Dotted lines join points between which no data were obtained

Fisheries Survey 1956

Government Printer 1956

PLATE 16



GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1951

N.B. 1. Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey, 1956. Government Printer, 1956

PLATE 16

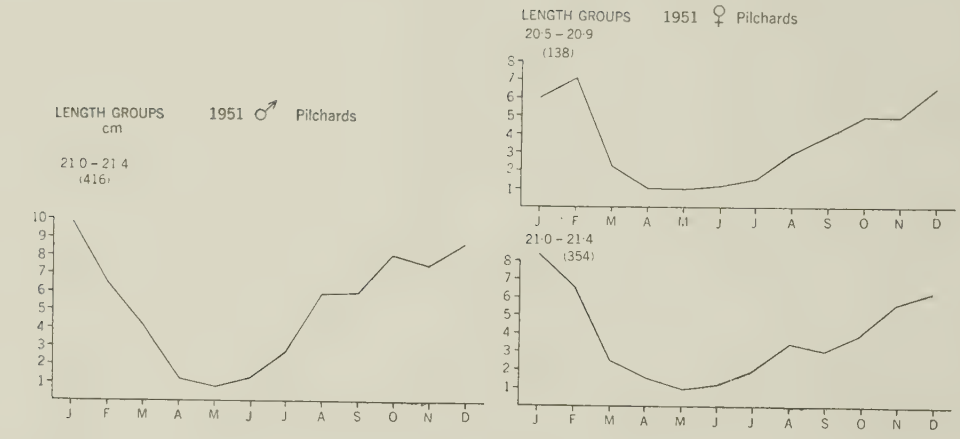
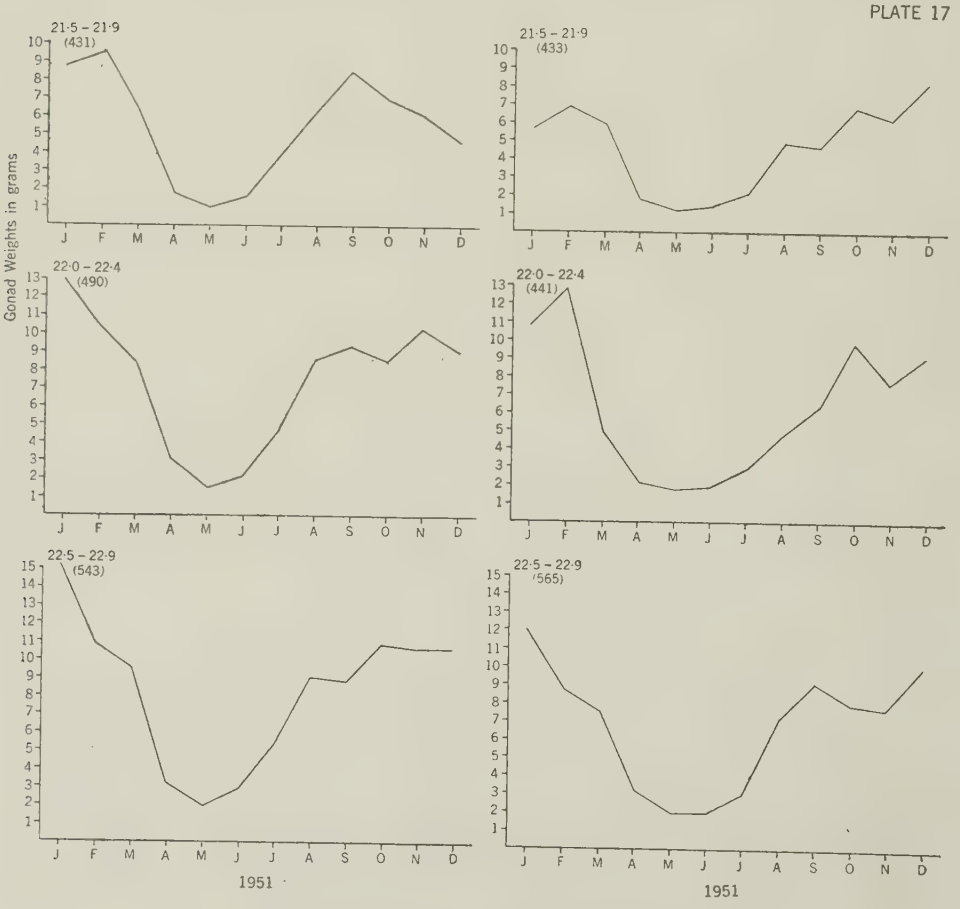


PLATE 17



GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1951

N.B. 1. Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey, 1956.

Government Printer, 1956

PLATE 17

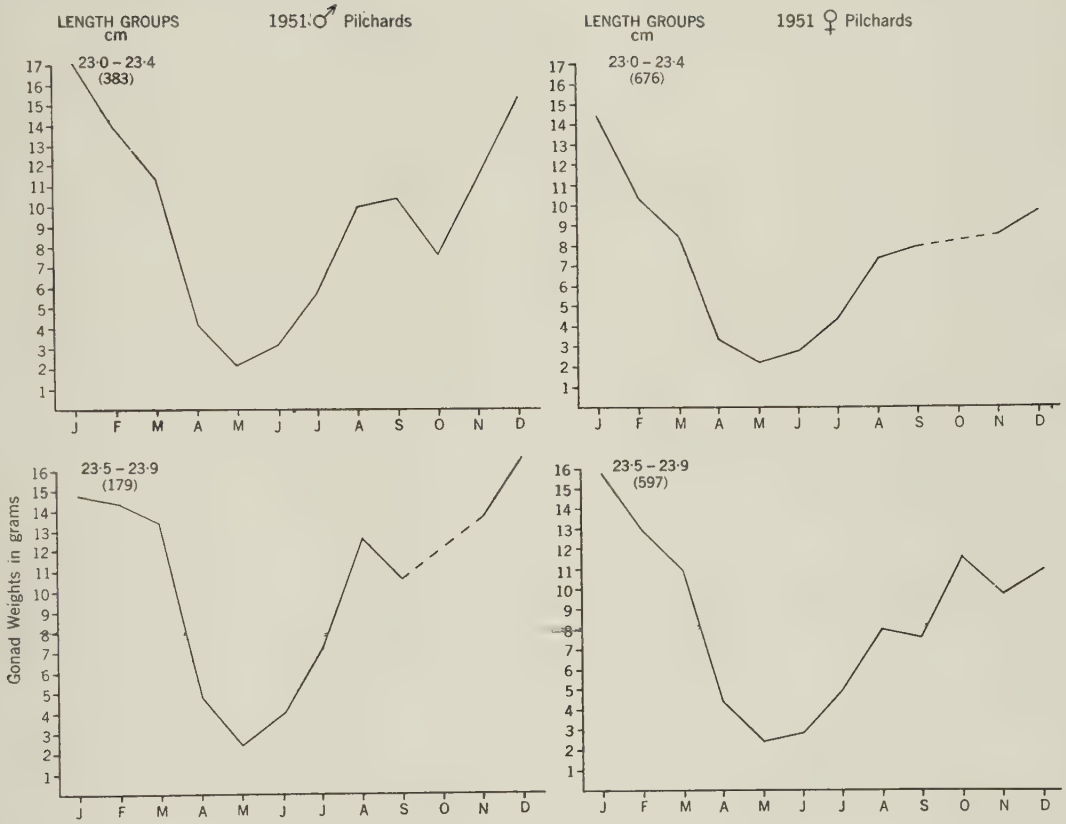
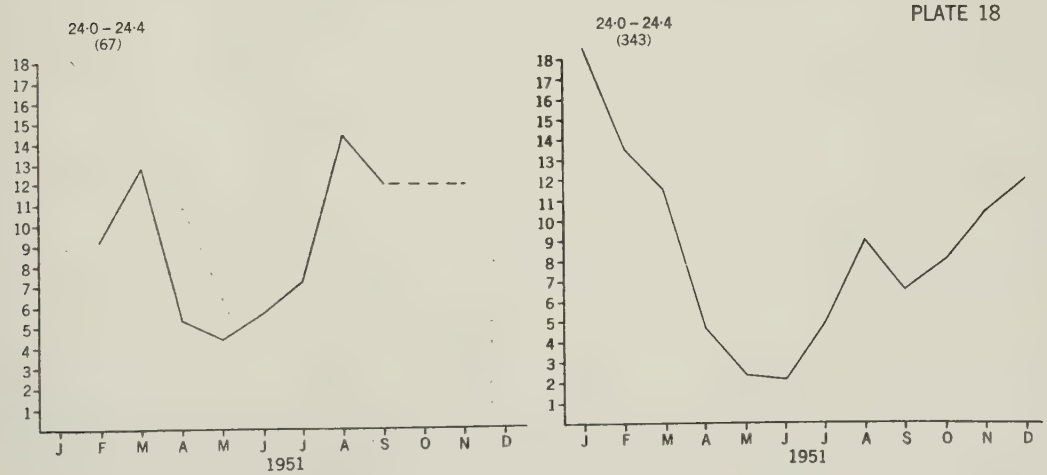

LENGTH GROUPS cm
1951 ♂ Pilchards
23·0 – 23·4 (383)
LENGTH GROUPS cm
1951 ♀ Pilchards
23·0 – 23·4 (676)
23·5 – 23·9 (179)
23·5 – 23·9 (597)
Gonad Weights in grams
J F M A M J J A S O N D

PLATE 18



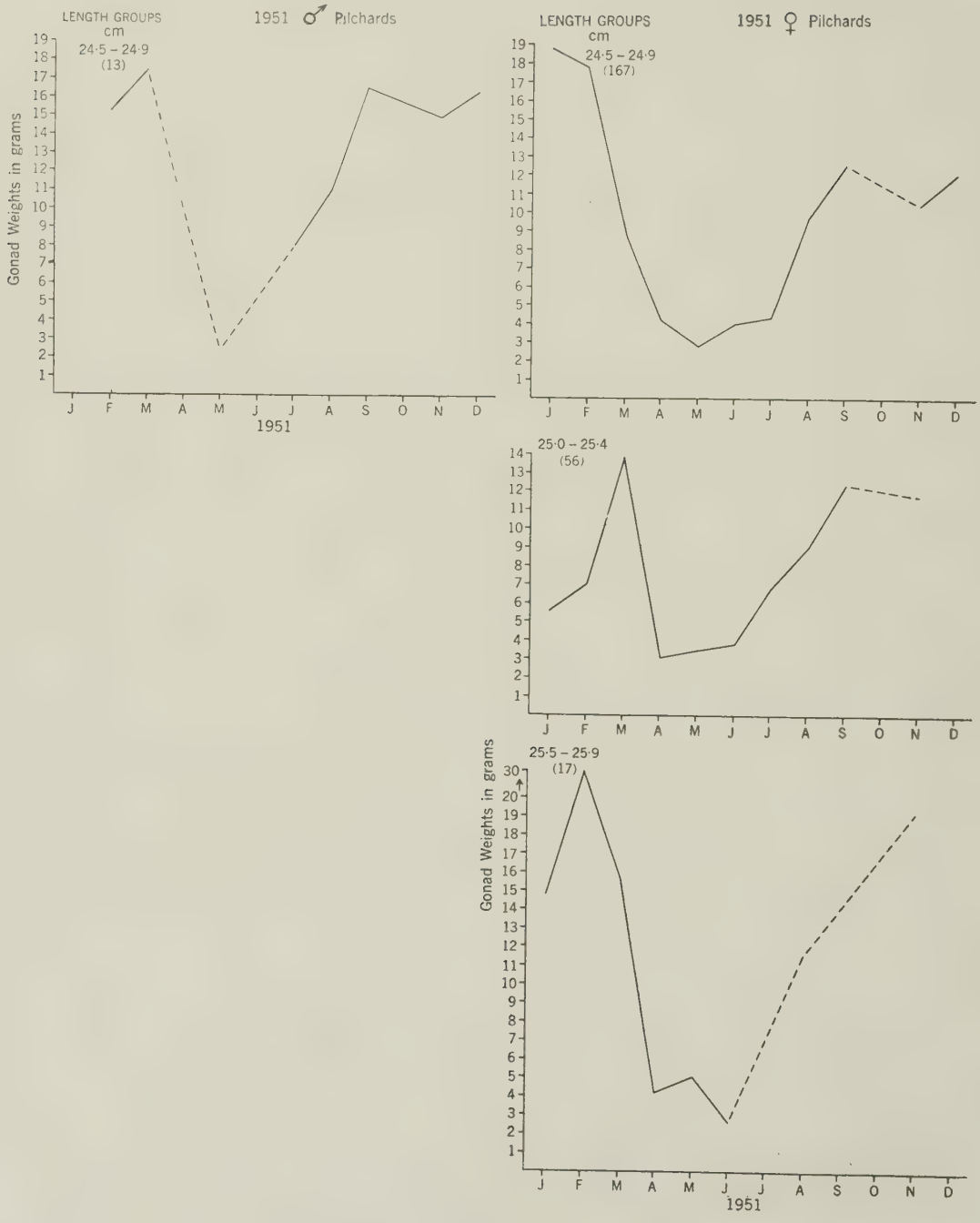
GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1951

N.B. 1. Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey. 1956.

Government Printer, 1956.

PLATE 18.



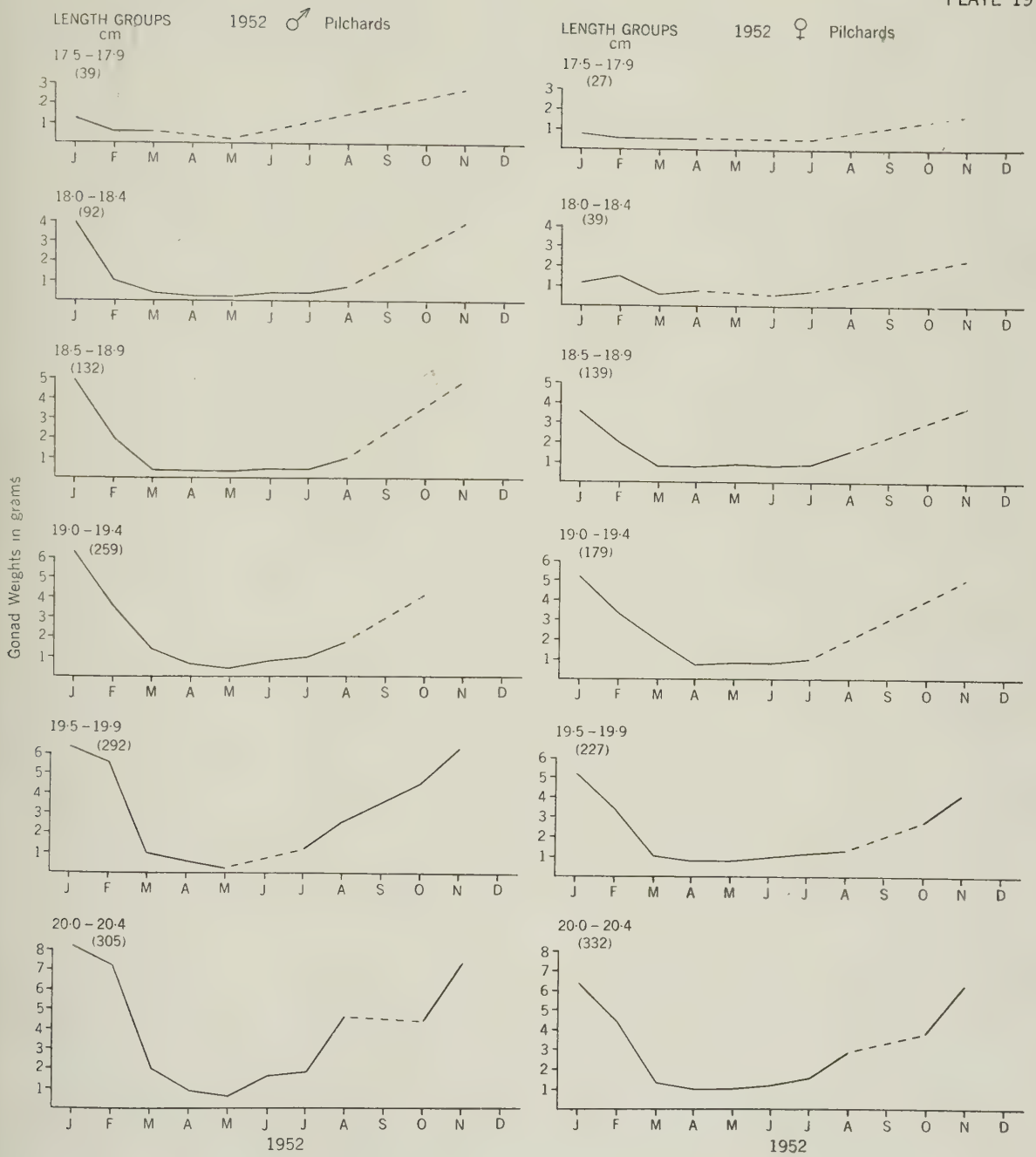
GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1951

N.B. 1. Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 19



GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1952

N.B. 1. Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 19

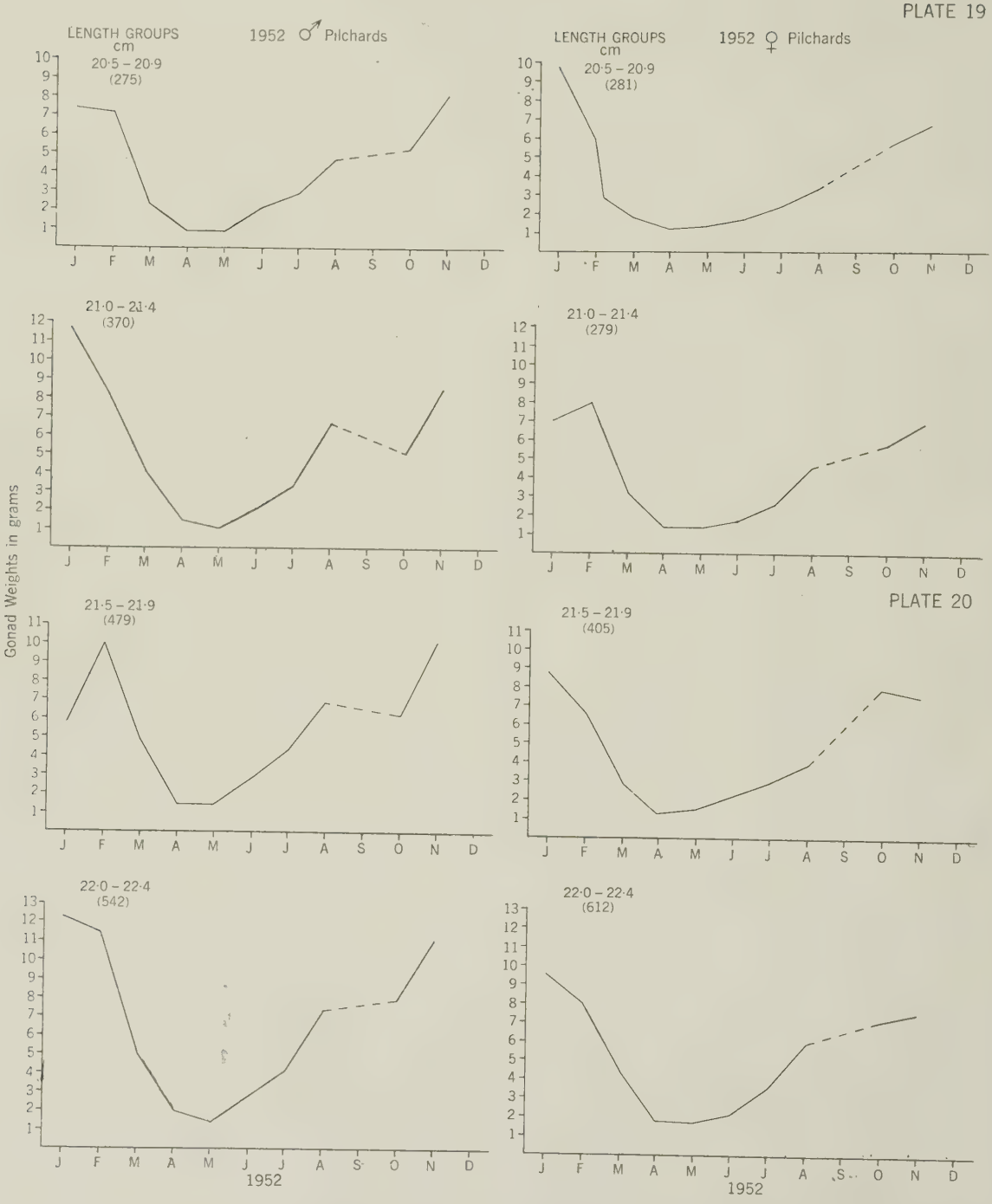


PLATE 20

GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1952

N.B. 1 Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey. 1956

Government Printer, 1956

PLATE 20

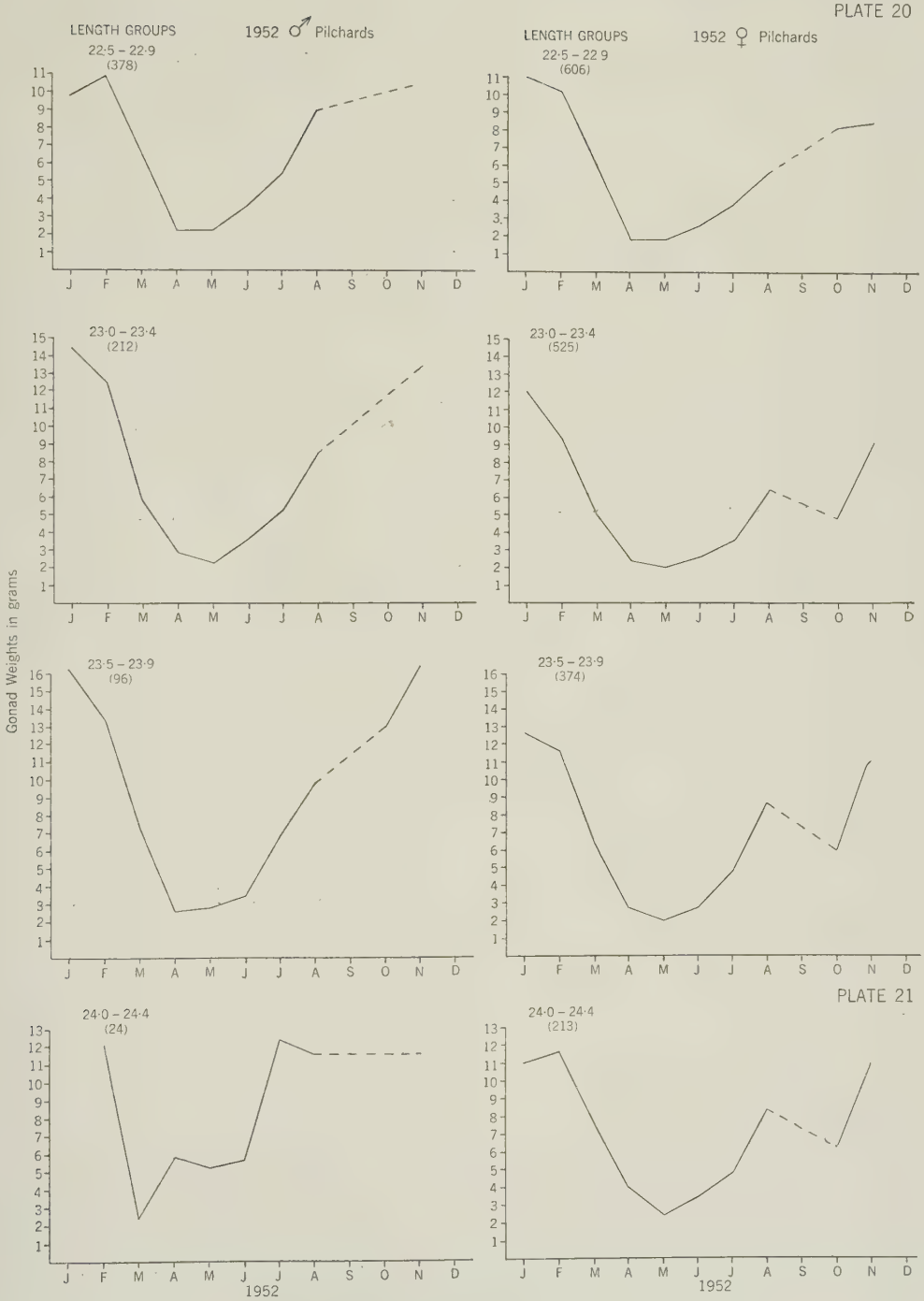


PLATE 21

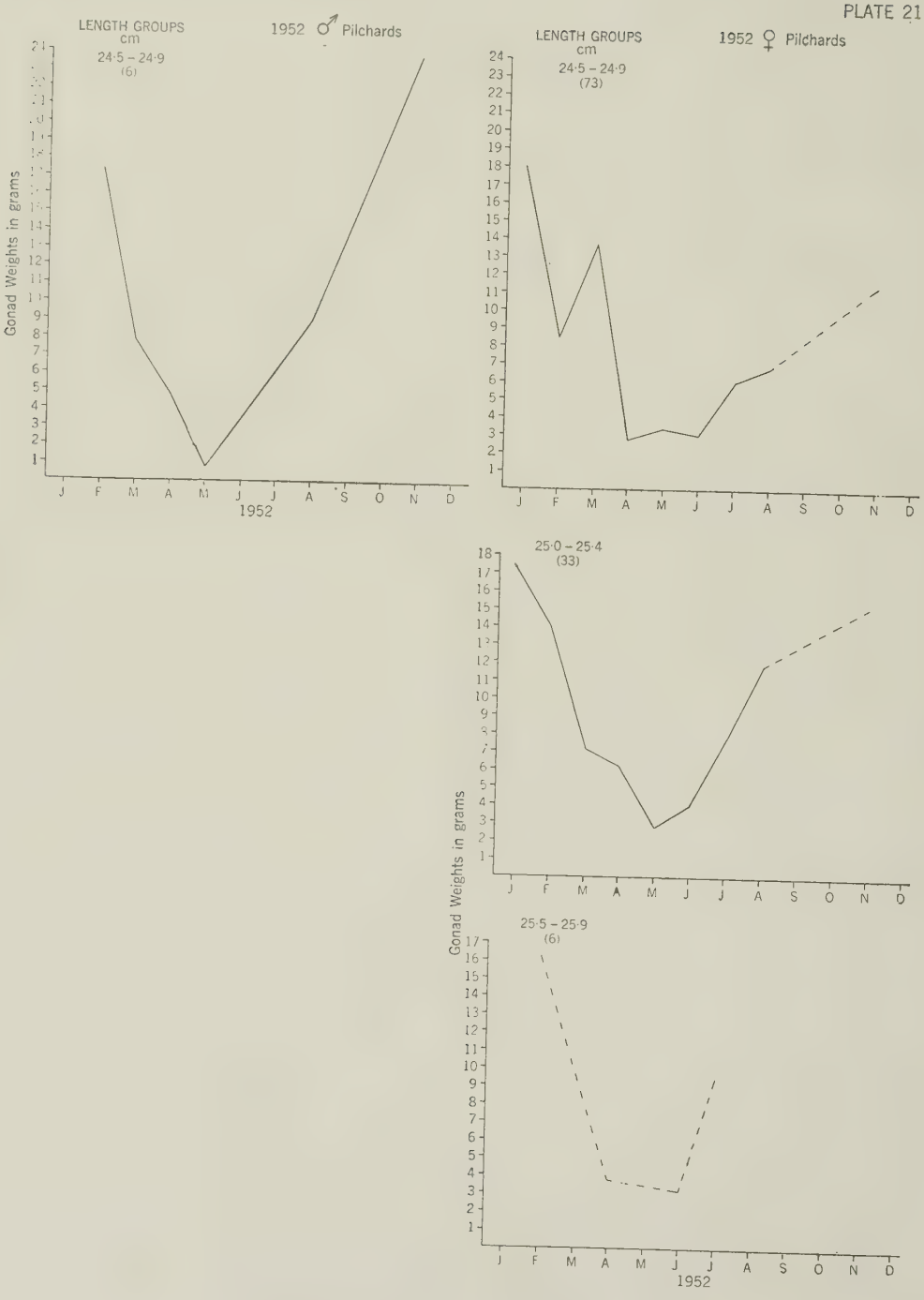
GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1952

N.B. 1 Figures in brackets indicate numbers of fish examined
2 Dotted lines join points between which no data were obtained

Trigsurvey 1956.

Government Printer 1956

PLATE 21



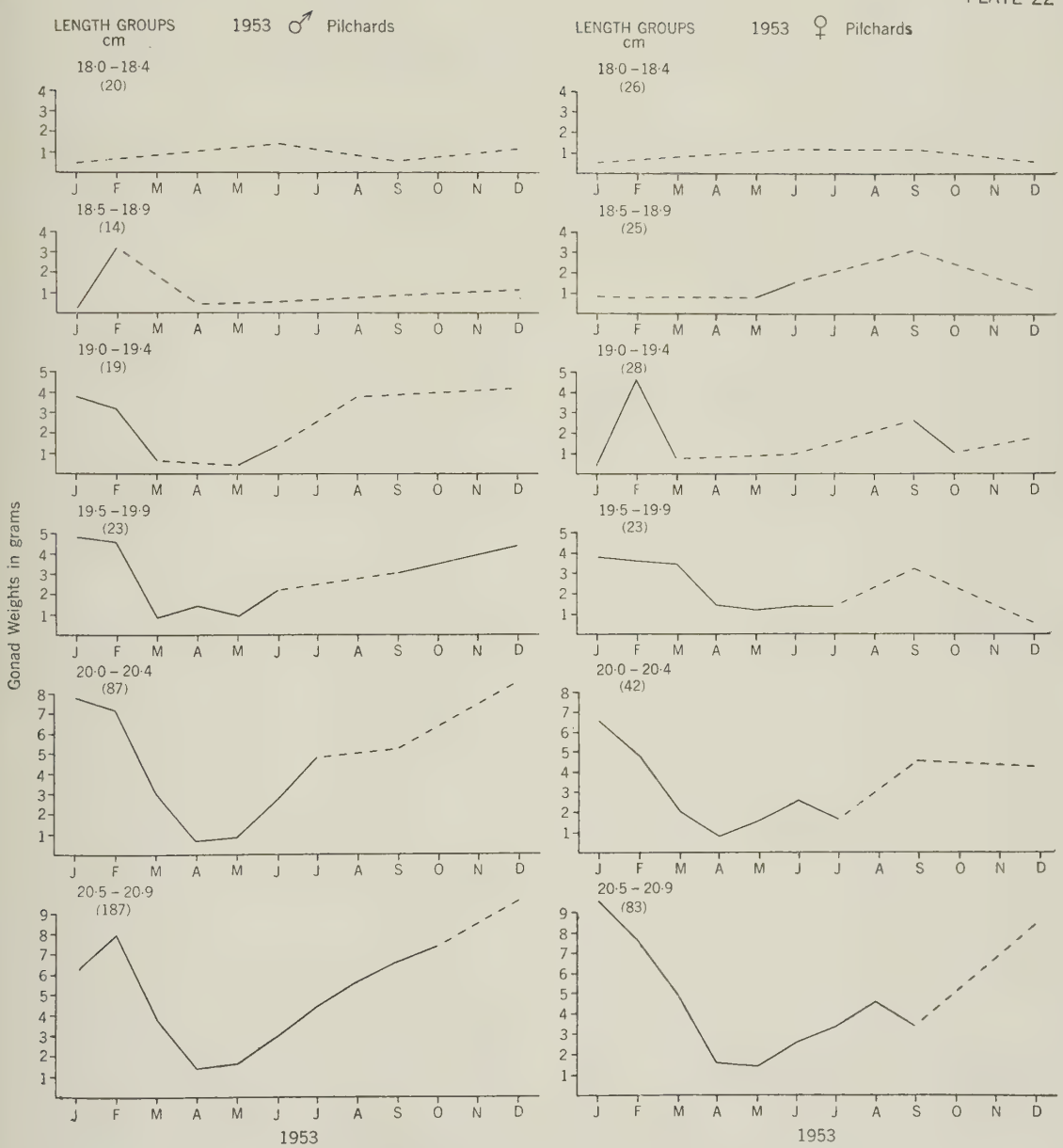
GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1952

N.B. 1. Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey 1956.

Government Printer, 1956.

PLATE 22



GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1953

N.B. 1. Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey. 1956. Government Printer, 1956.

PLATE 22

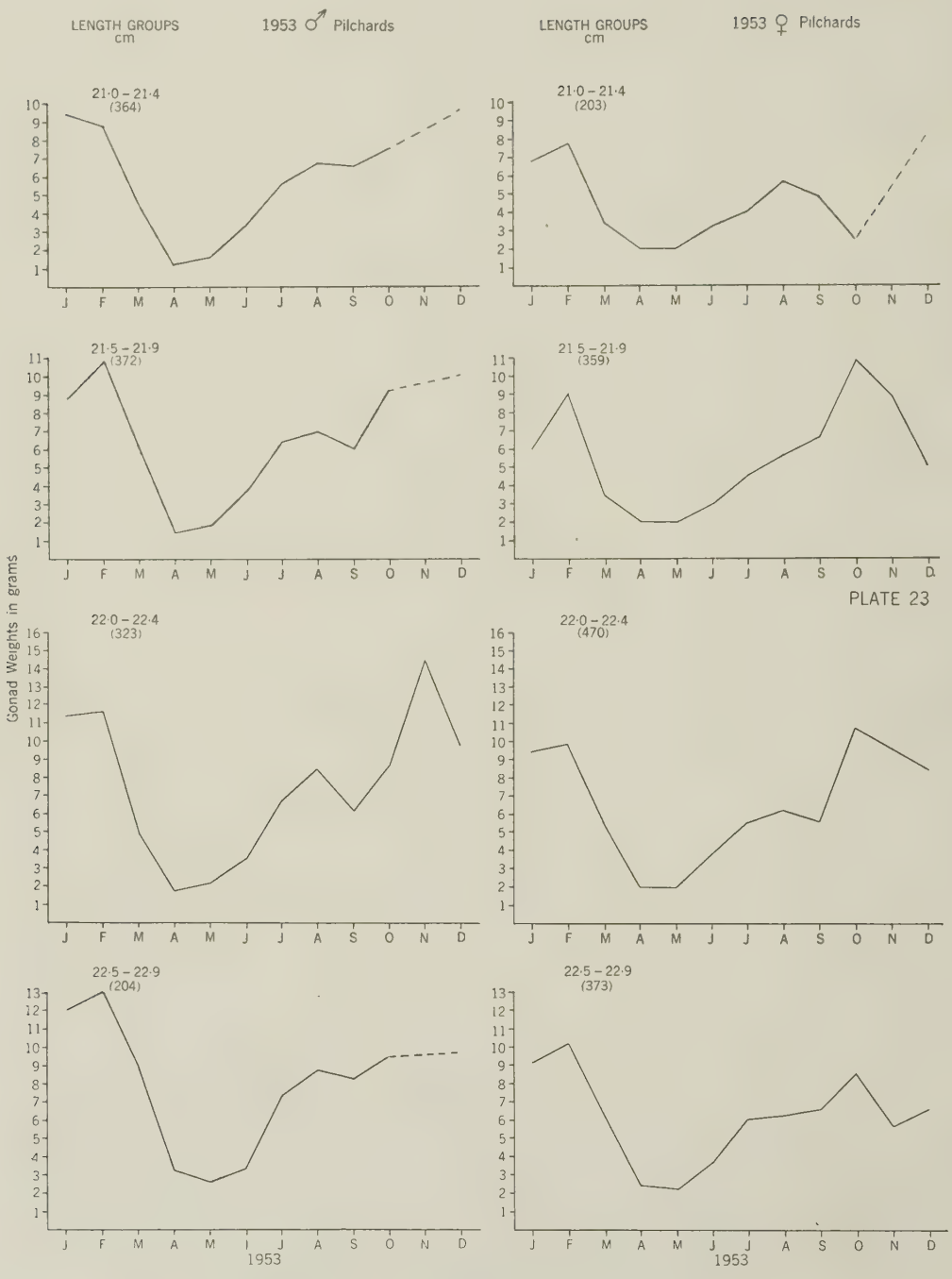


PLATE 23

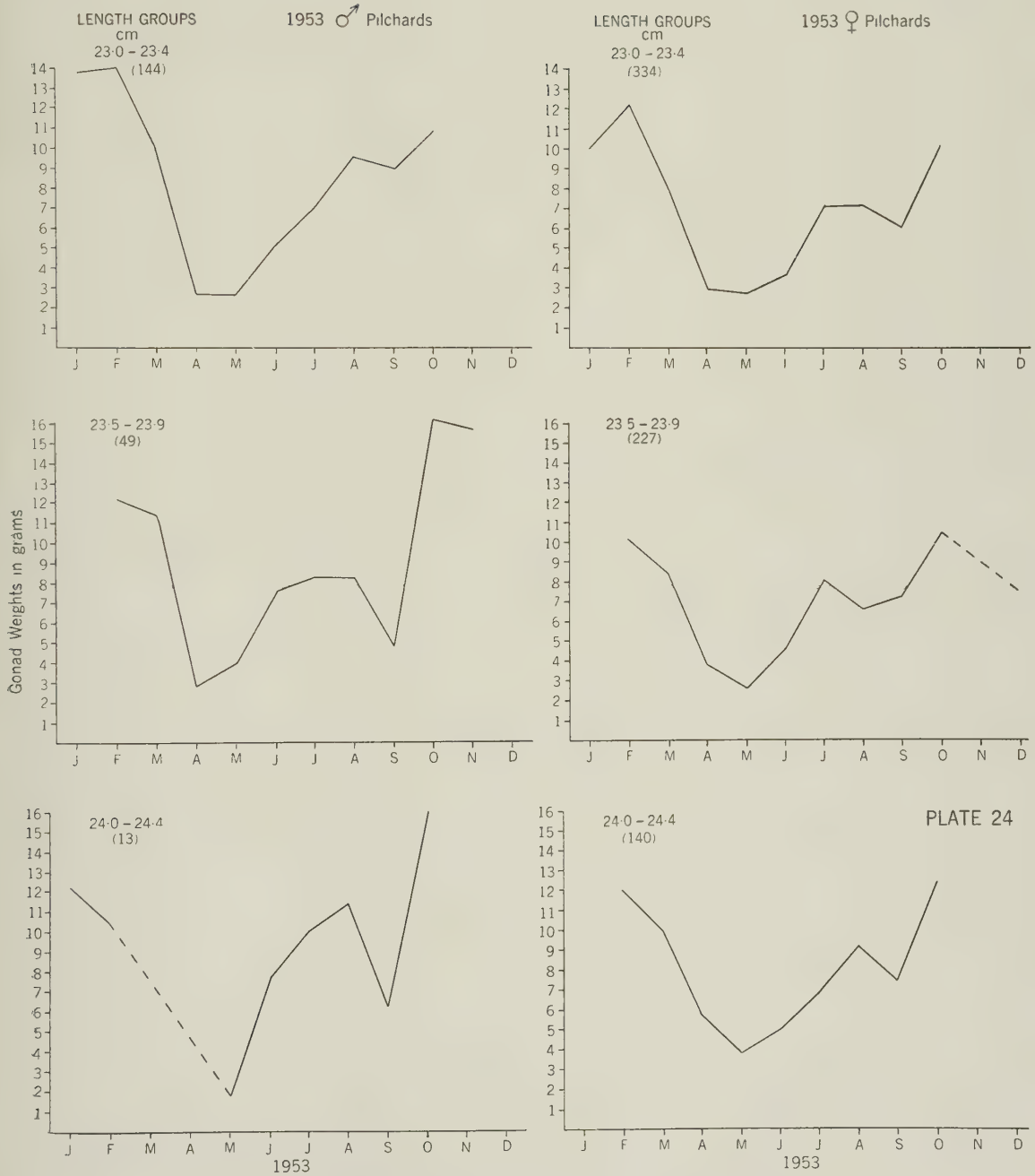
GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1953

N.B. 1. Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey 1956.

Government Printer, 1956

PLATE 23



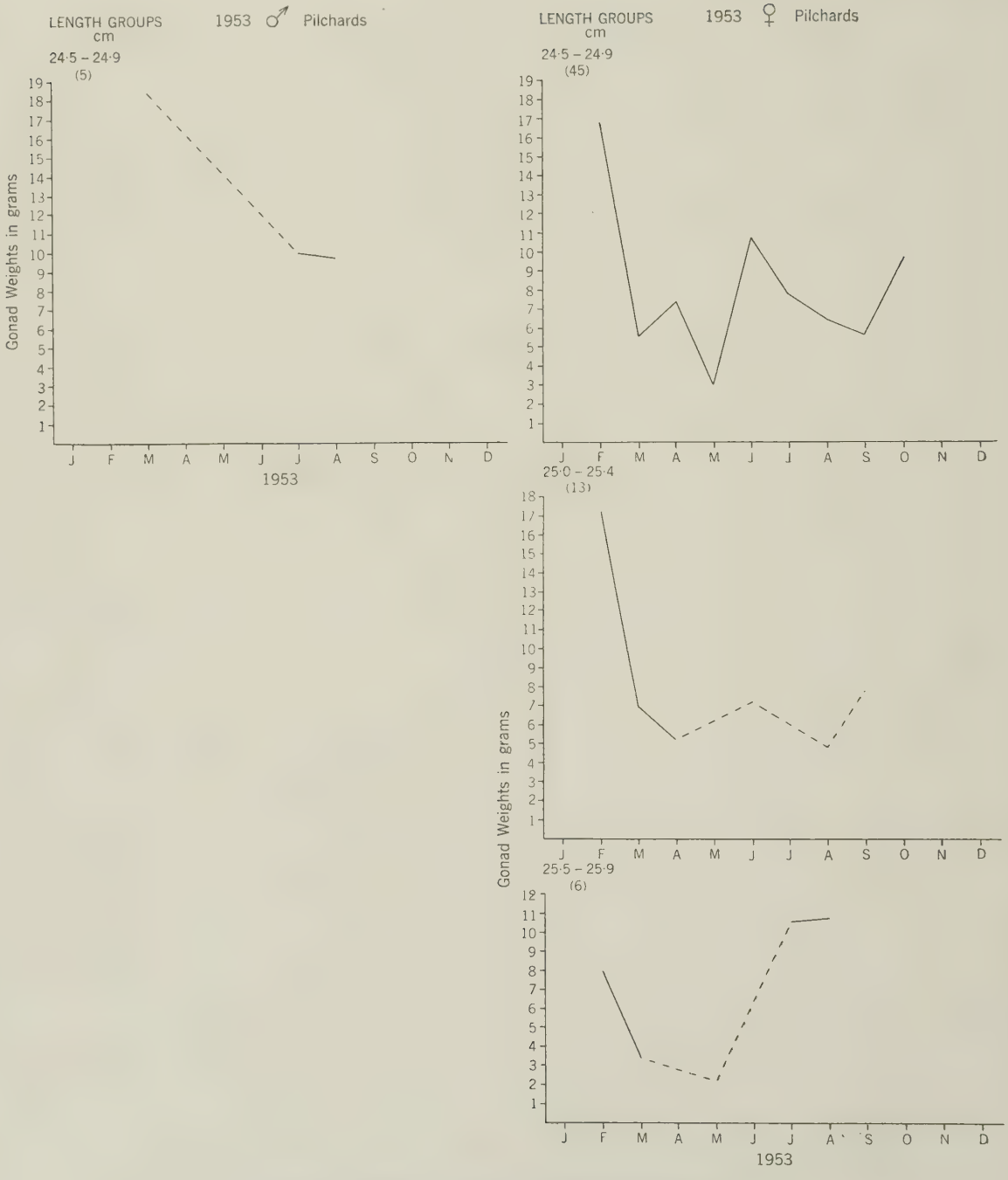
GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1953

N.B 1 Figures in brackets indicate numbers of fish examined
2 Dotted lines join points between which no data were obtained

Trigsurvey, 1956.

Government Printer, 1956

PLATE 24

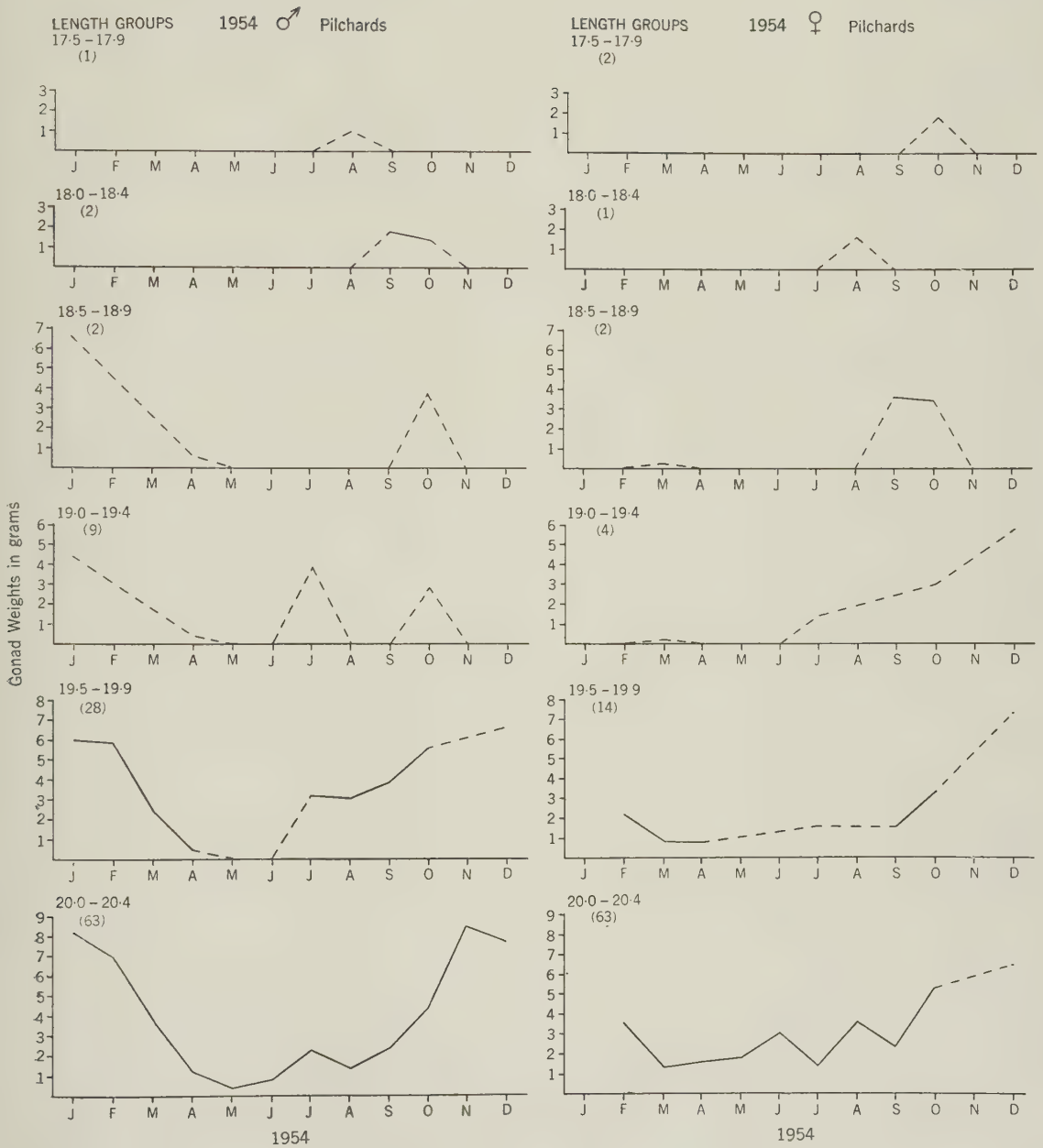


GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1953

N.B. 1. Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey, 1956. Government Printer, 1956.

PLATE 25



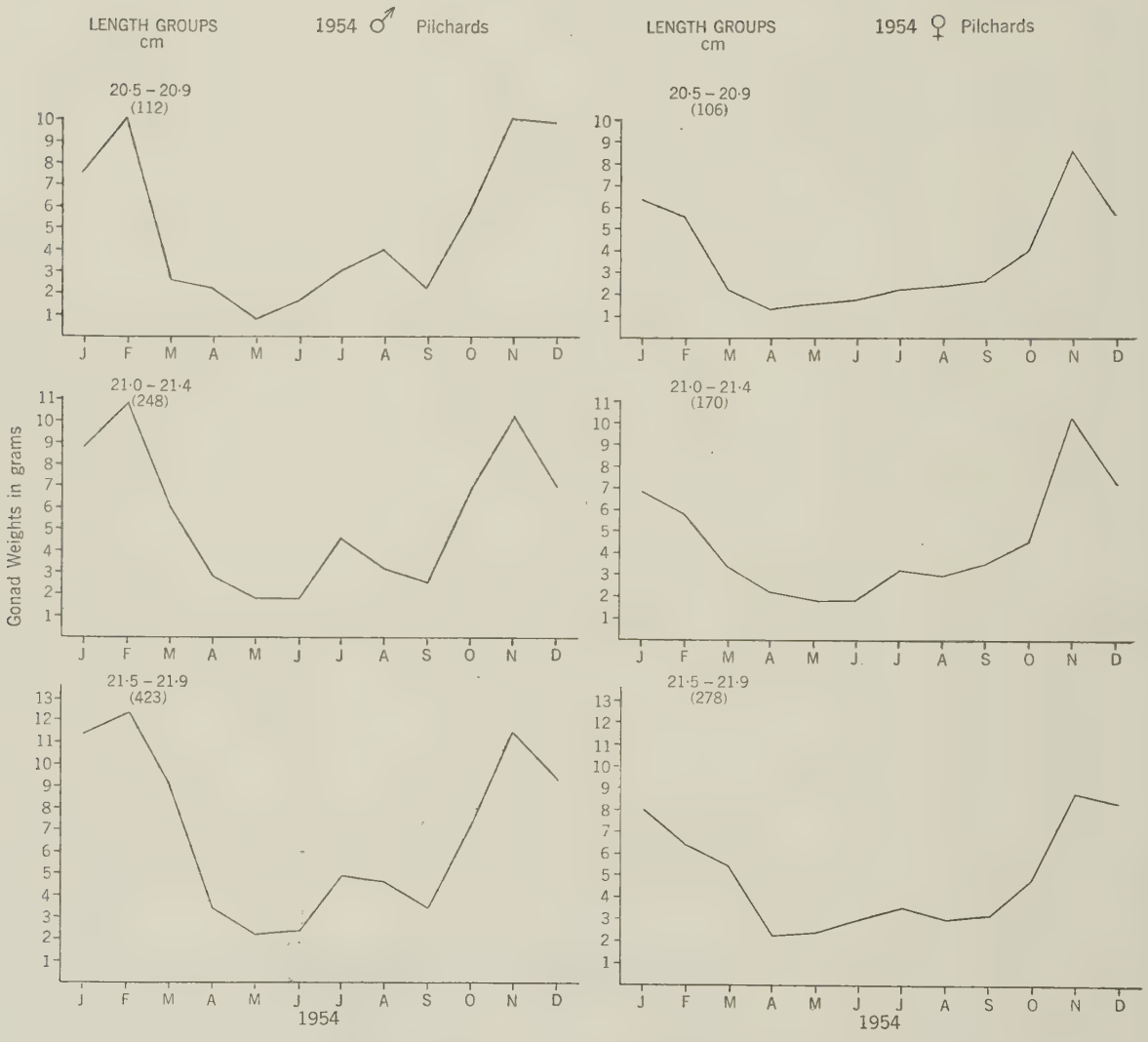
GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1954

N.B. 1. Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey, 1956.

Government Printer, 1956

PLATE 25


LENGTH GROUPS cm
1954 ♂ Pilchards
LENGTH GROUPS cm
1954 ♀ Pilchards
20·5 – 20·9 (112)
20·5 – 20·9 (106)
21·0 – 21·4 (248)
21·0 – 21·4 (170)
21·5 – 21·9 (423)
21·5 – 21·9 (278)
Gonad Weights in grams
J F M A M J J A S O N D
1954

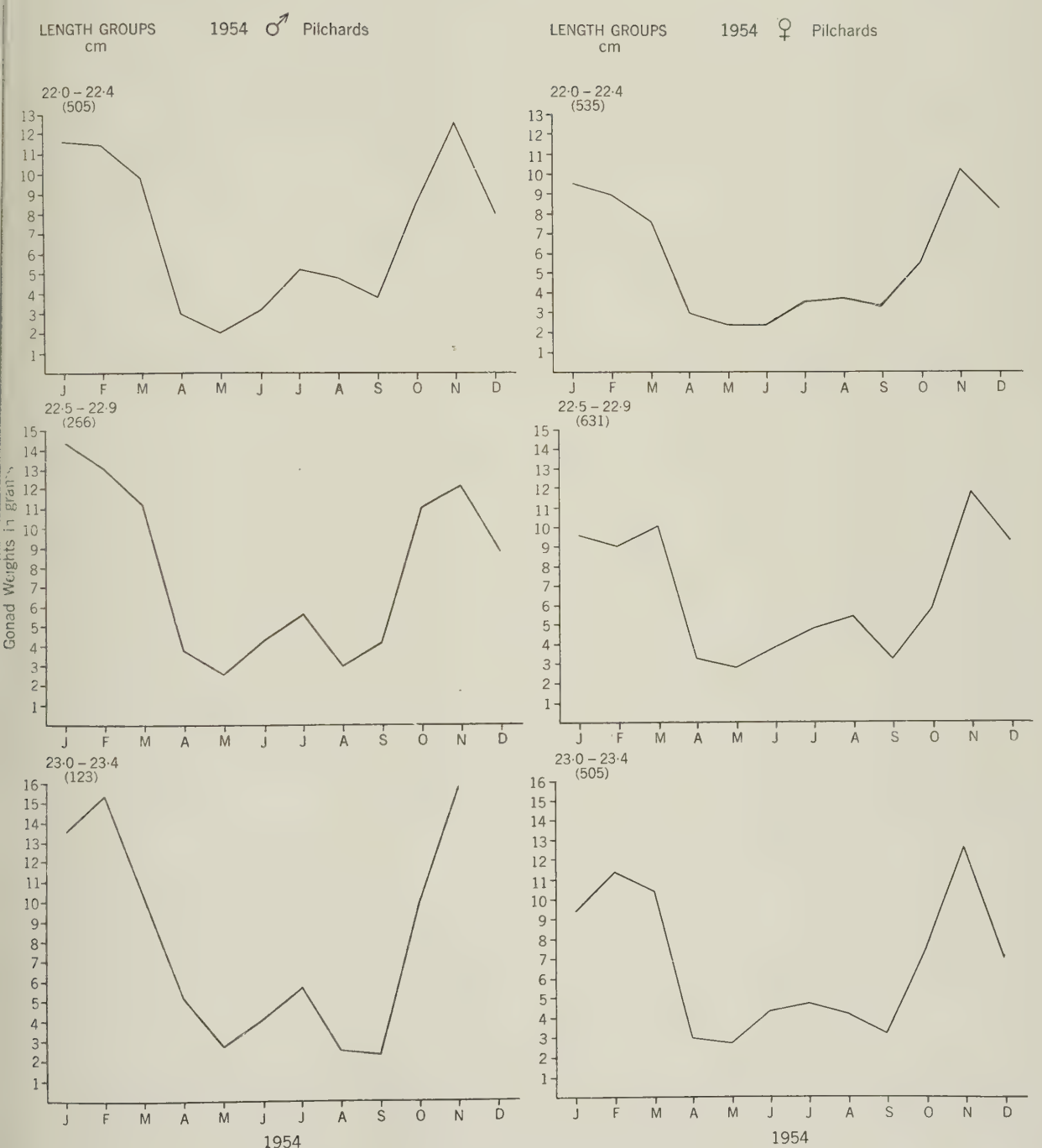
CONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1954

N.B. 1. Figures in brackets indicate numbers of fish examined

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 26

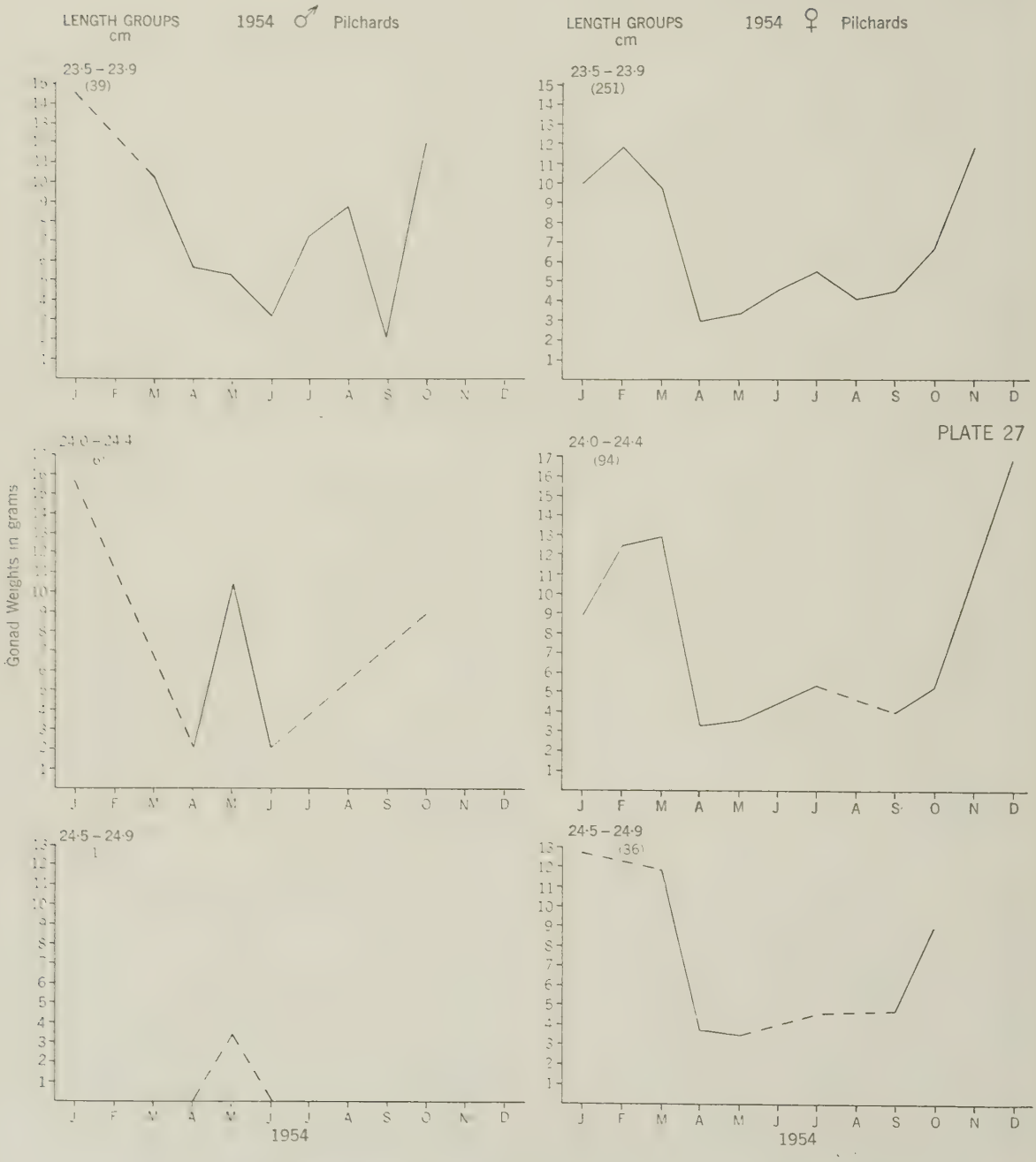

LENGTH GROUPS cm
1954 ♂ Pilchards
22·0 – 22·4 (505)
22·5 – 22·9 (266)
23·0 – 23·4 (123)
LENGTH GROUPS cm
1954 ♀ Pilchards
22·0 – 22·4 (535)
22·5 – 22·9 (631)
23·0 – 23·4 (505)
Gonad Weights in grams
J F M A M J J A S O N D
1954

GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1954

N.B. 1. Figures in brackets indicate numbers of fish examined

Trigsurvey, 1956. Government Printer, 1956.

PLATE 26



GONAD WEIGHTS IN RELATION TO LENGTH GROUPS FOR 1954

N.B. 1. Figures in brackets indicate numbers of fish examined
2. Dotted lines join points between which no data were obtained

Trigsurvey. 1956.

Government Printer, 1956

PLATE 28

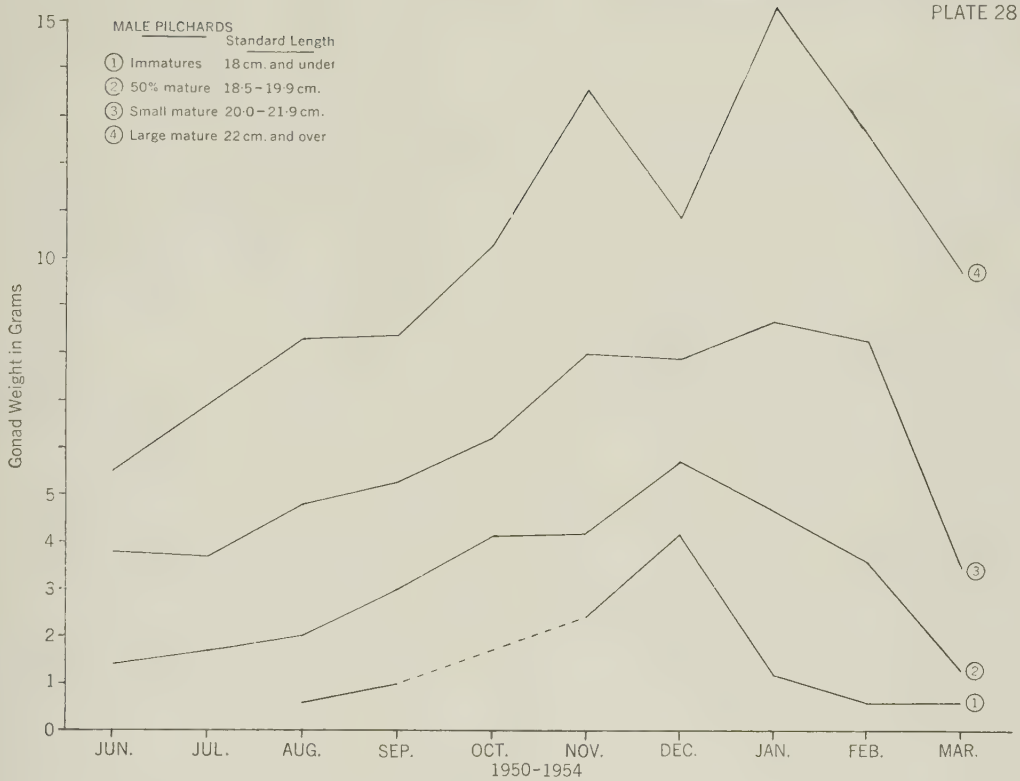


FIG. 1 MALES

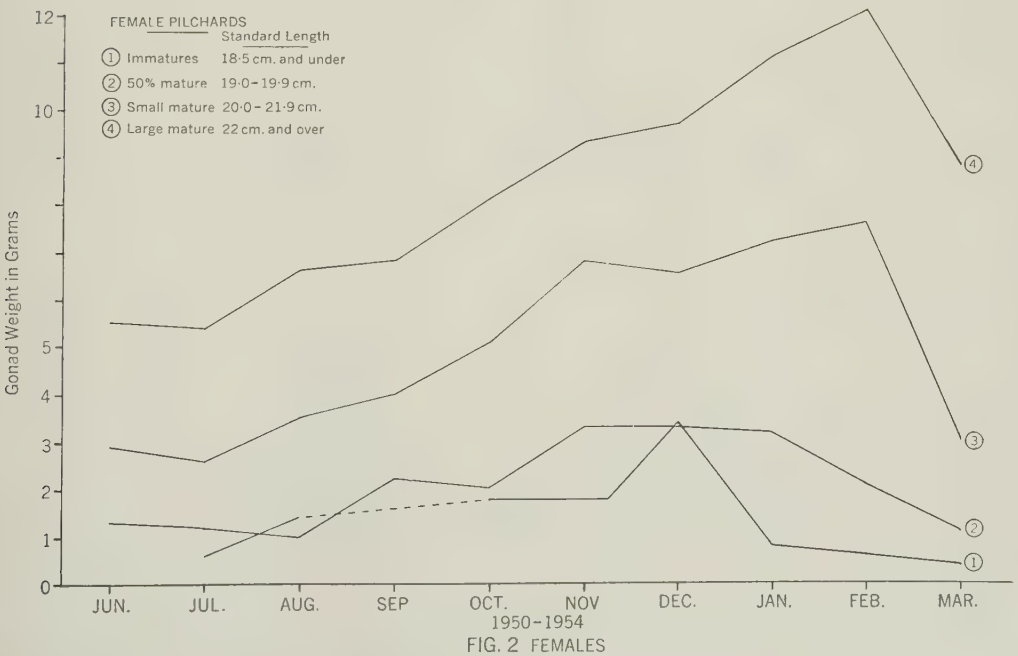


FIG. 2 FEMALES

GONAD WEIGHTS IN RELATION TO SEXUAL MATURITY.

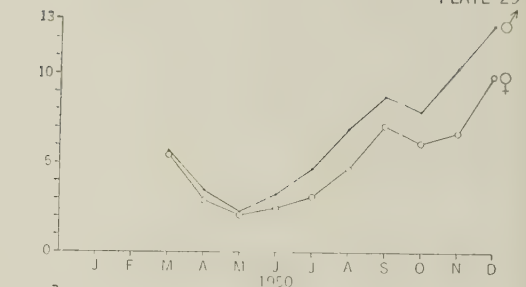
Trigsurvey, 1956. Government Printer, 1956

PLATE 28

FIG. 3 GONAD WEIGHTS IN RELATION TO SEXUAL MATURITY

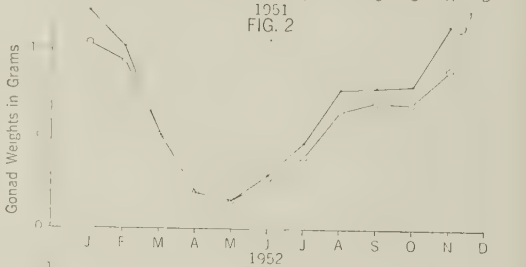
Trigsurvey, 1956. Government Printer, 1956.

PLATE 29



1950
FIG. 1

1951
FIG. 2



1952
FIG. 3

1953
FIG. 4

1954
FIG. 5

GONAD WEIGHTS OF LENGTH GROUPS 21·0-24·5 CM. (STANDARD LENGTH), 1950-1954.

Trigsurvey, 1956 Government Printer, 1956.

PLATE 30

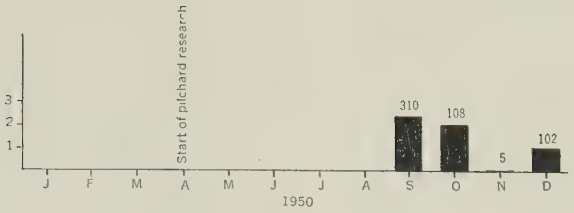


FIG.1

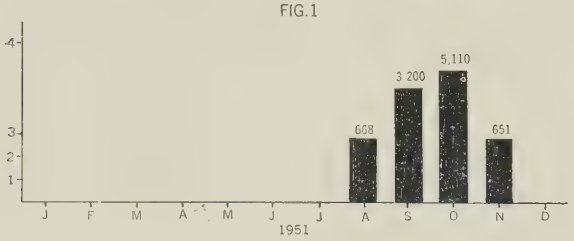


FIG.2

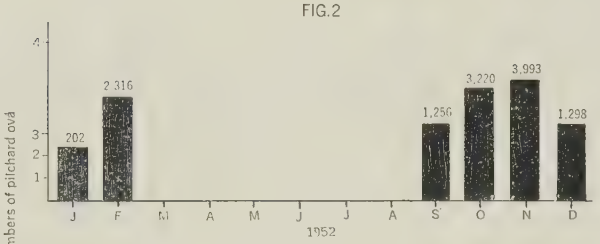


FIG.3

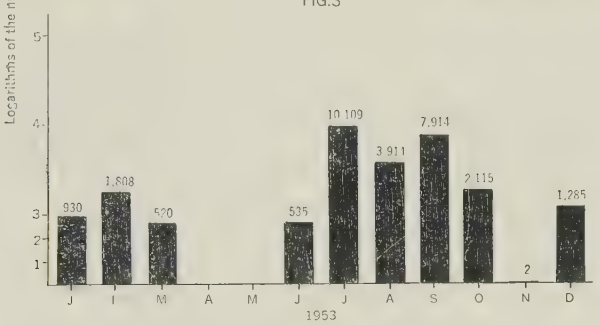


FIG.4

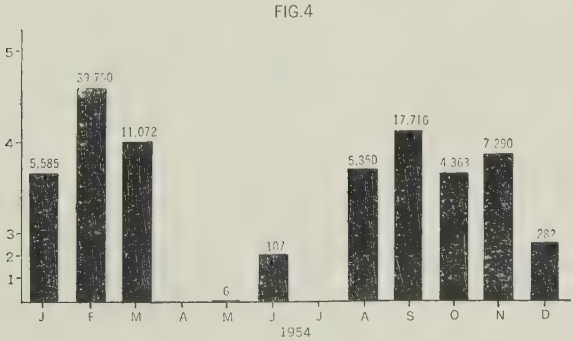


FIG.5

NUMBERS OF PILCHARD OVA PER MONTH FROM ROUTINE OFFSHORE STATIONS

Trigsurvey, 1956. Government Printer, 1956.

PLATE 31

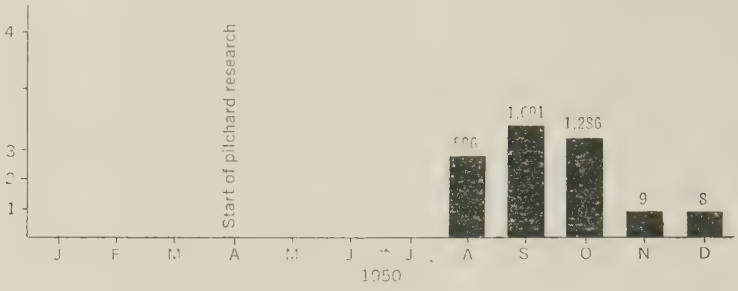


FIG. 1

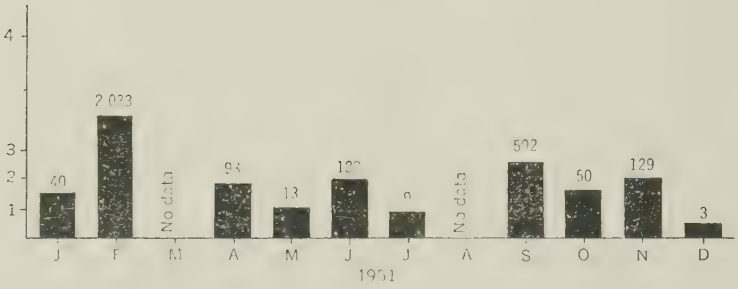


FIG. 2

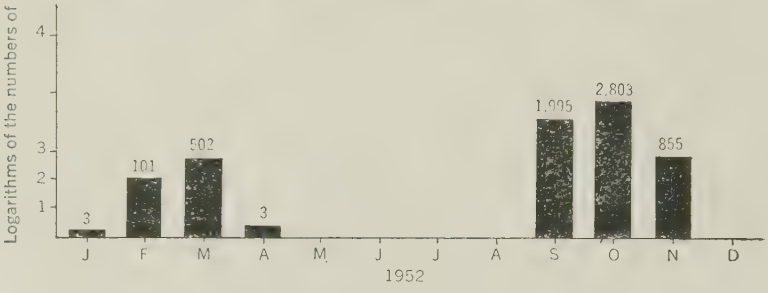


FIG. 3

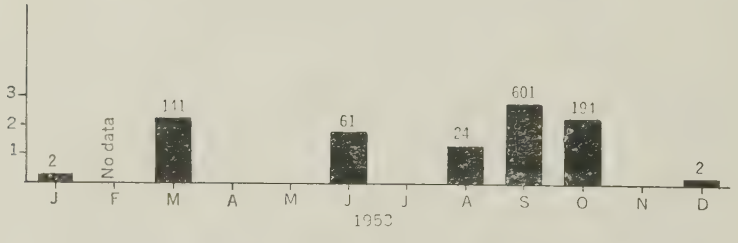


FIG. 4

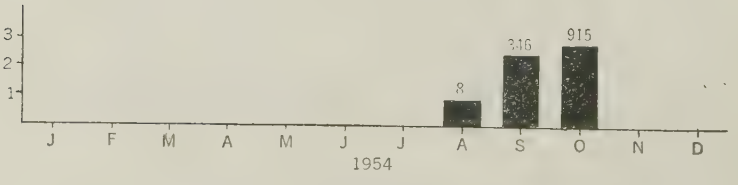
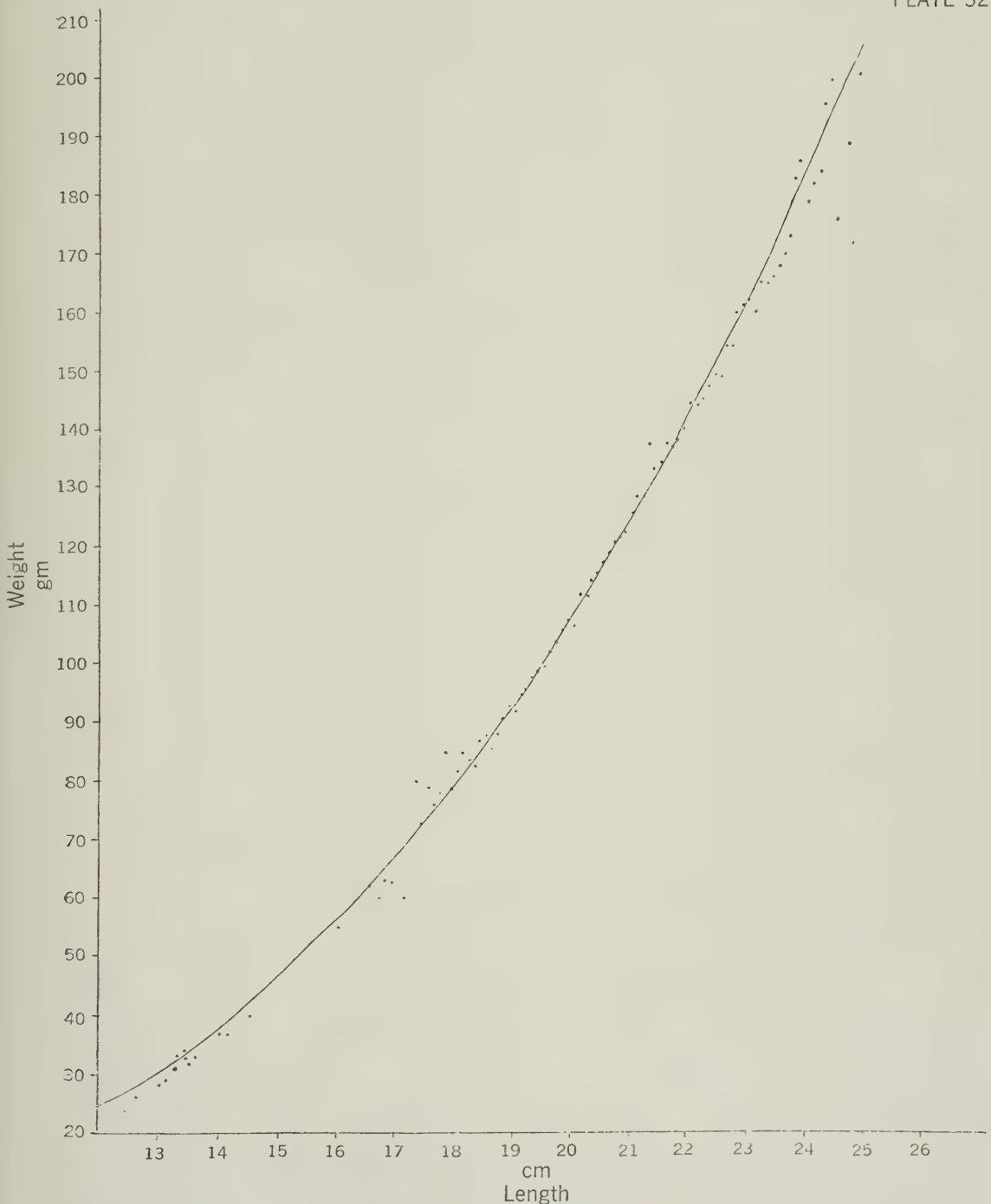


FIG.5

NUMBERS OF PILCHARD OVA PER MONTH
FROM ROUTINE INSHORE STATIONS

Trigsurvey, 1956. Government Printer, 1956.

PLATE 32

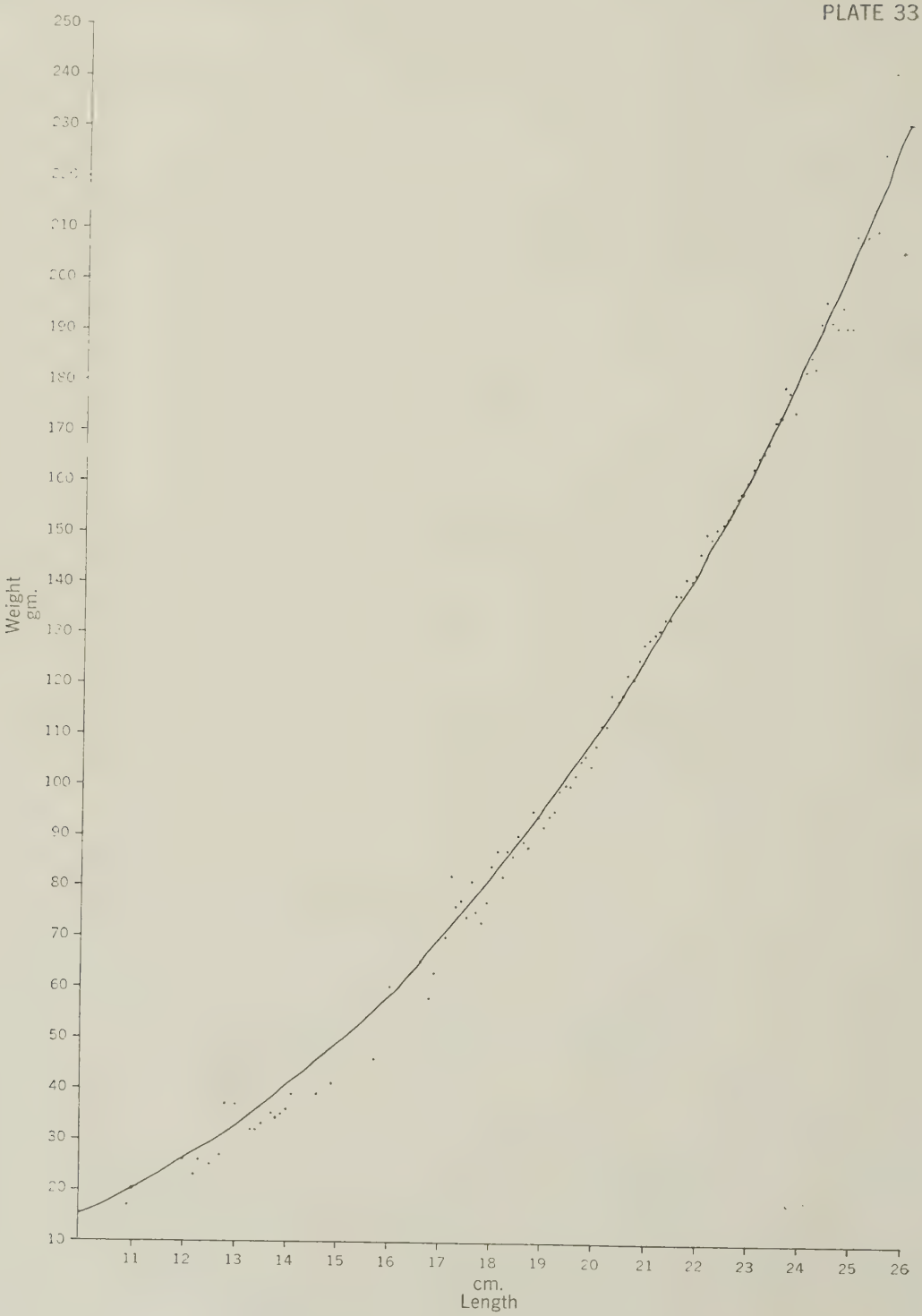


WEIGHT–LENGTH CURVE FOR MALE PILCHARDS 1952

(Curve fitted by the formula $W = .01686\ \ell^{2.928}$)

Trigsurvey, 1956. Government Printer, 1956.

PLATE 33



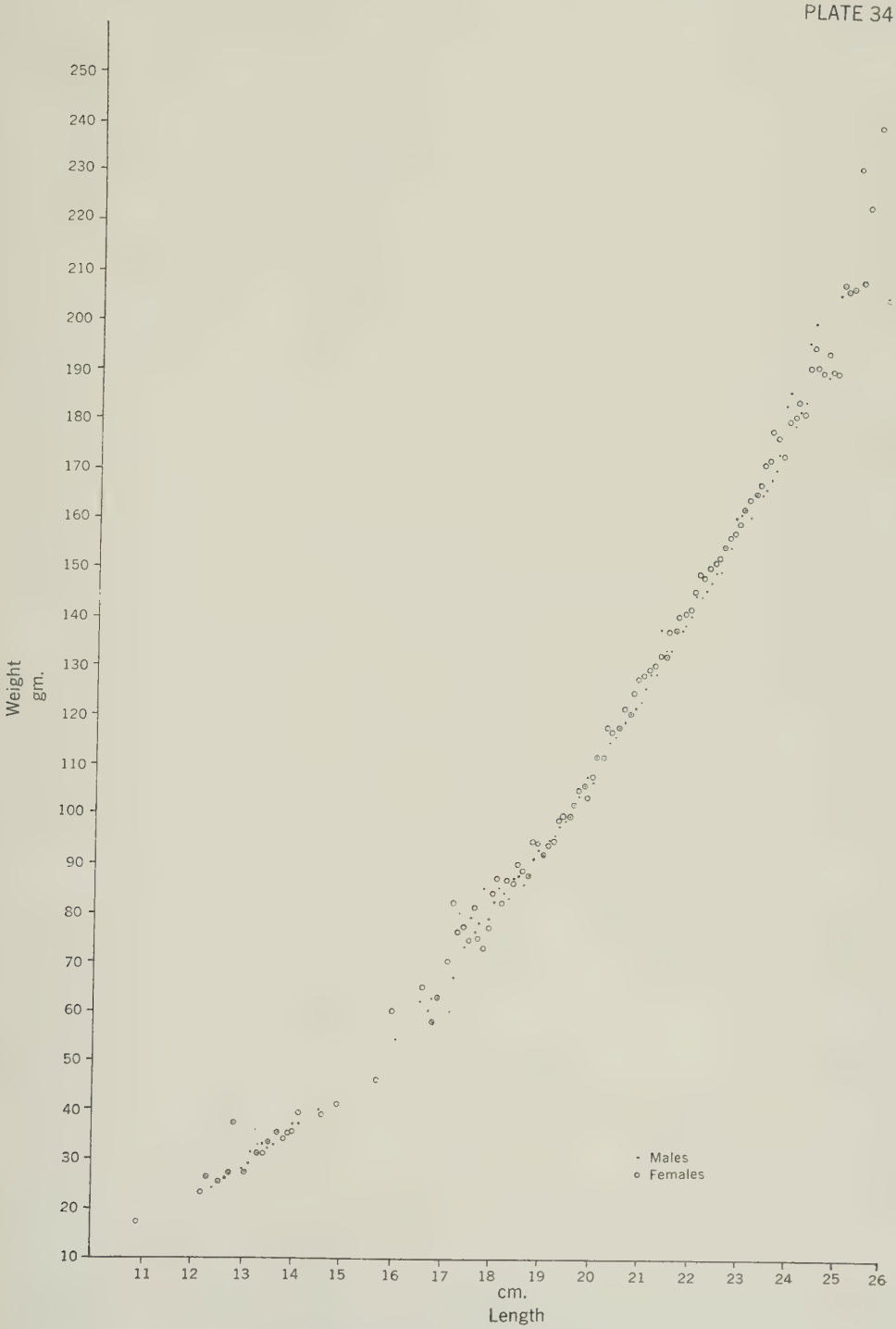
WEIGHT-LENGTH CURVE FOR FEMALE PILCHARDS, 1952

(Curve fitted by the formula $W=\cdot 02451\ell^{2\cdot 808}$)

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 34

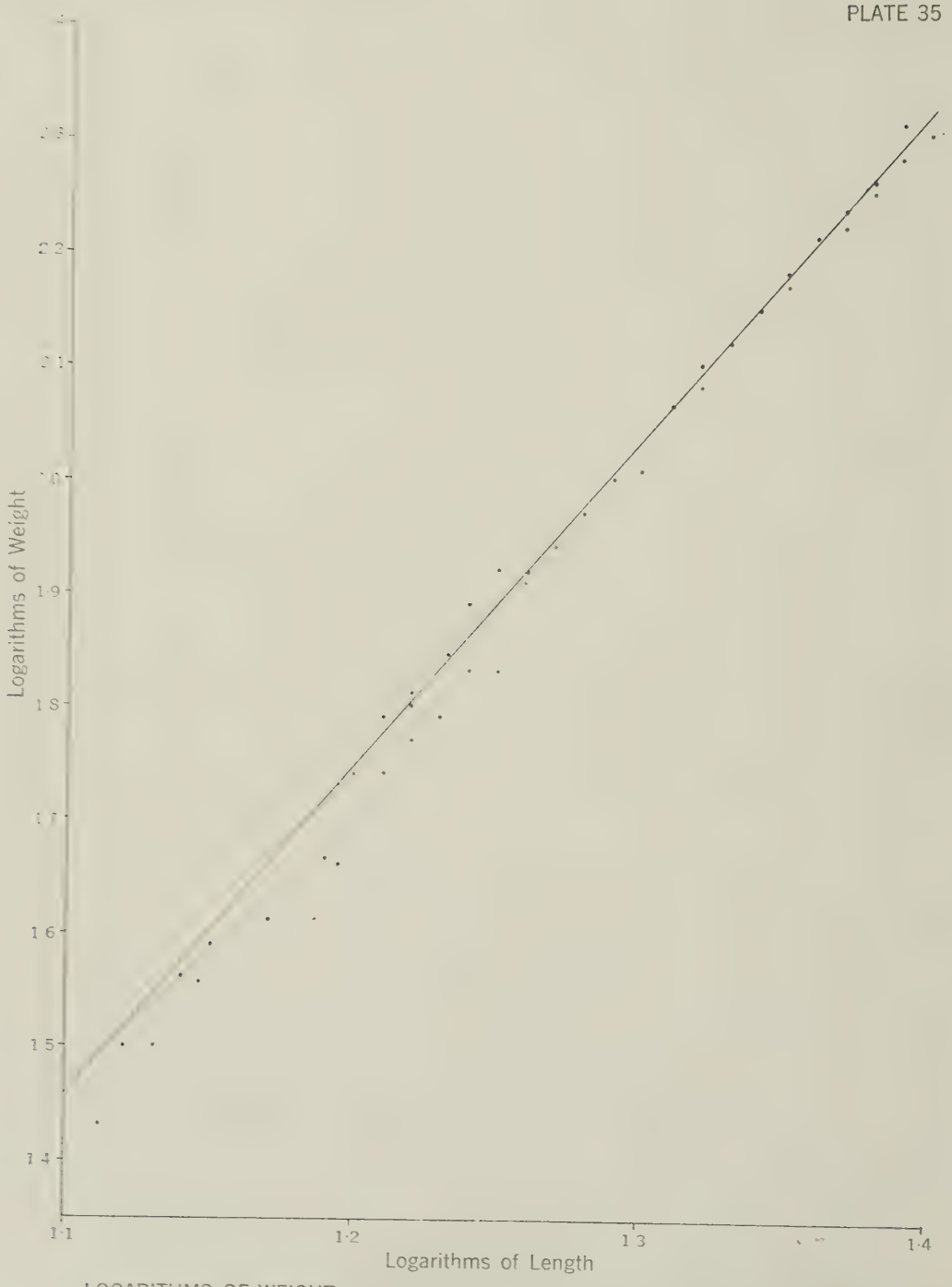


AVERAGE WEIGHT PER CENTIMETRE OF LENGTH
FOR MALE AND FEMALE PILCHARDS 1952

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 35

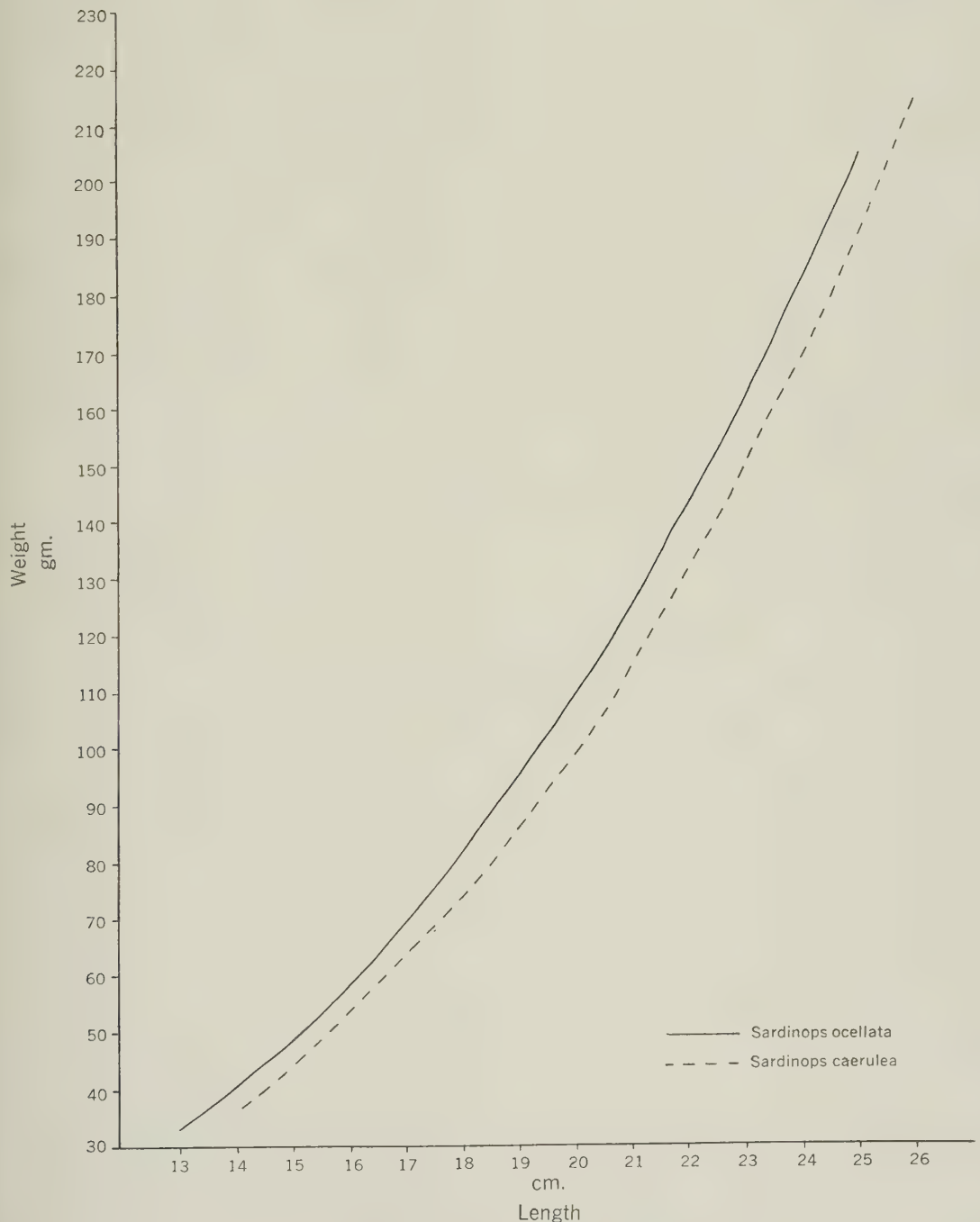


LOGARITHMS OF WEIGHT AND LENGTH OF MALE AND FEMALE PILCHARDS 1952.
(CURVE FITTED BY THE FORMULAE $Y = 2{\cdot}928X + \bar{2}{\cdot}2269$ and $Y = 2{\cdot}808X + \bar{2}{\cdot}3894$)

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 36



COMPARISON OF WEIGHT–LENGTH CURVES FOR FEMALE PILCHARDS 1952 AND FEMALE CALIFORNIA SARDINE 1928–29.

Trigsurvey, 1956. Government Printer, 1956.

PLATE 37 A

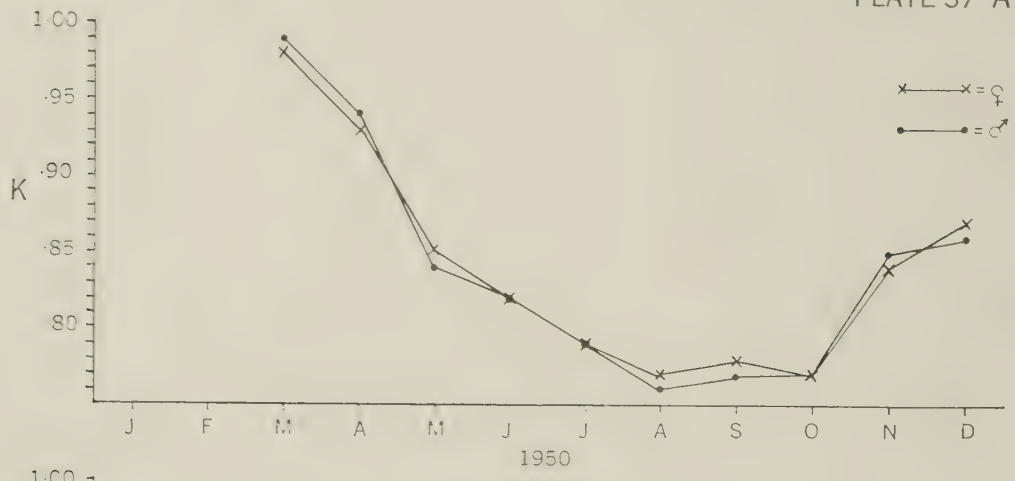


FIG.1

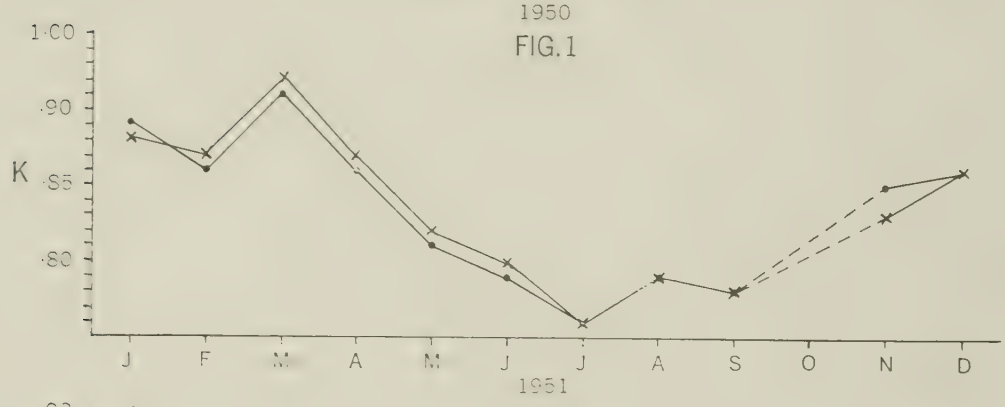


FIG.2

FIG.3

MEAN CONDITION FACTOR FOR ALL FISH

Trigsurvey, 1956. Government Printer, 1956.

PLATE 37 B

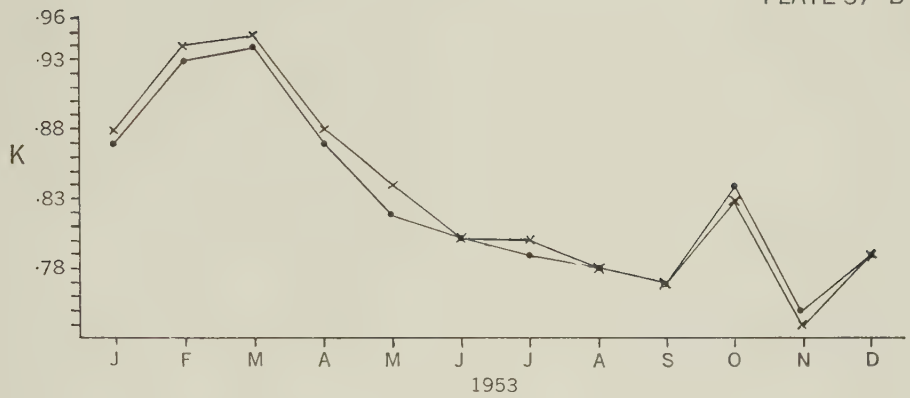


FIG.4

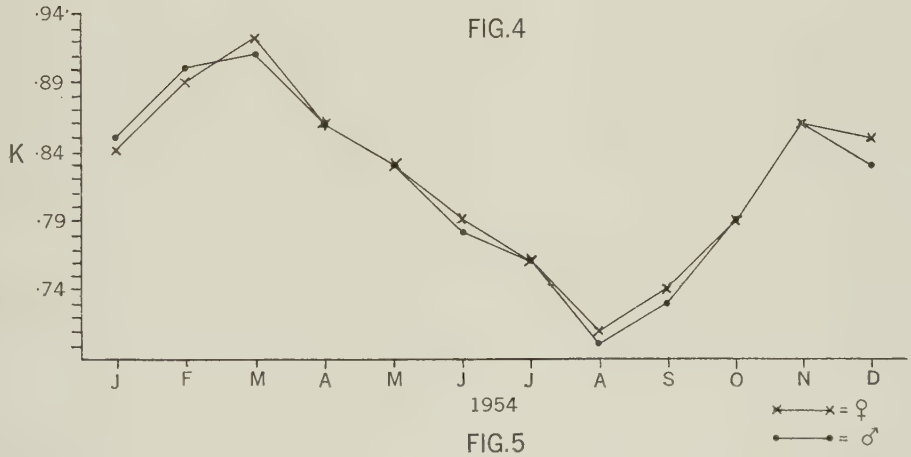


FIG.5

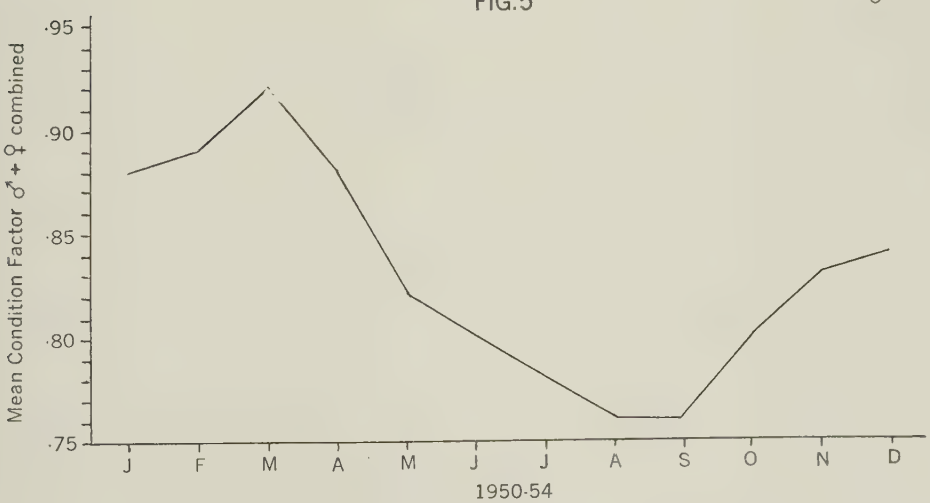
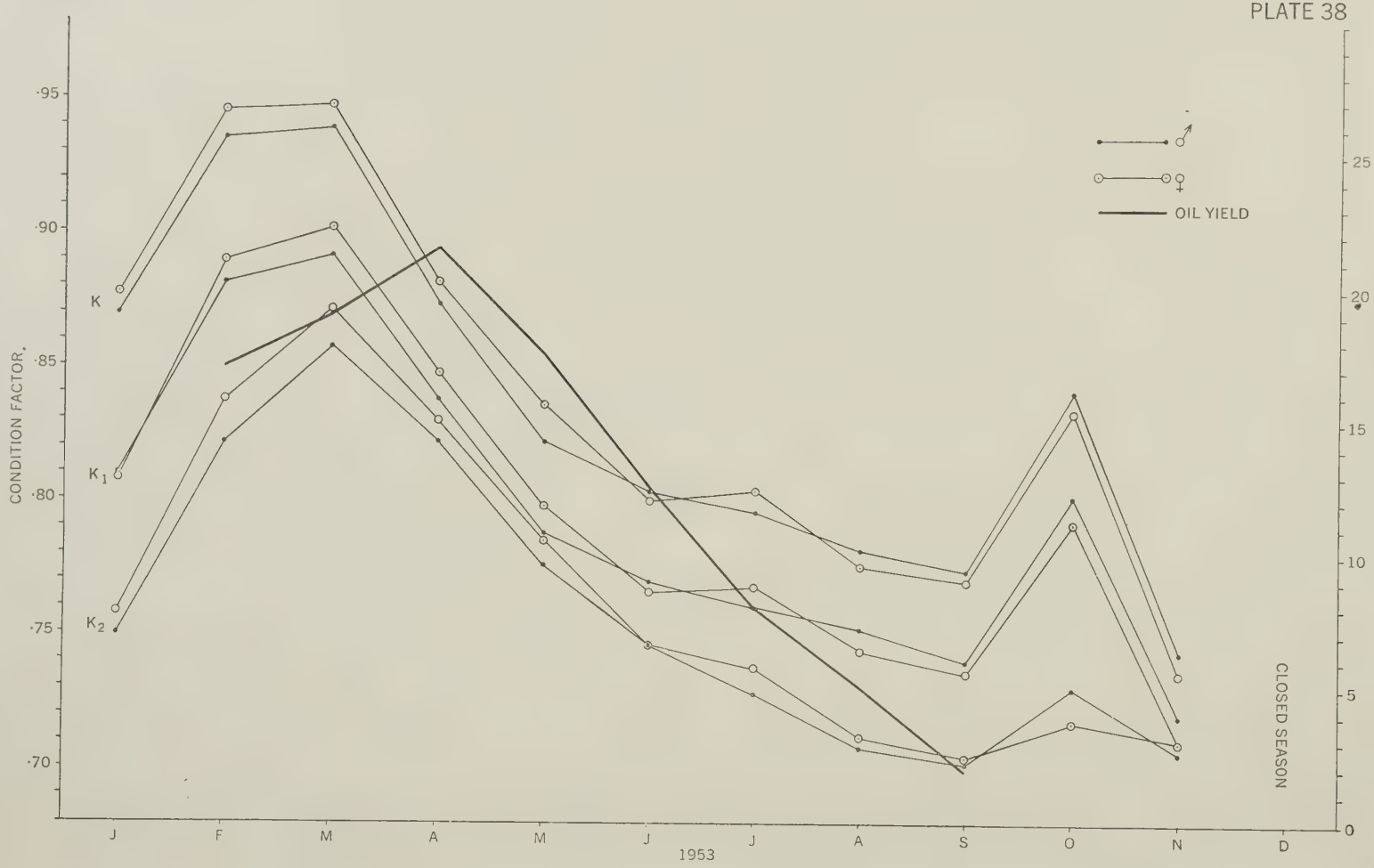


FIG.6

MEAN CONDITION FACTOR FOR ALL FISH 1950-54

Trigsurvey, 1956. Government Printer, 1956.

PLATE 38



COMPARISON OF K, K_1 AND K_2 FOR ALL FISH, TOGETHER WITH OIL YIELD.

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 39

MEAN K FOR LENGTH GROUPS 21·5 – 24·5 CM. AND OIL YIELD

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 40

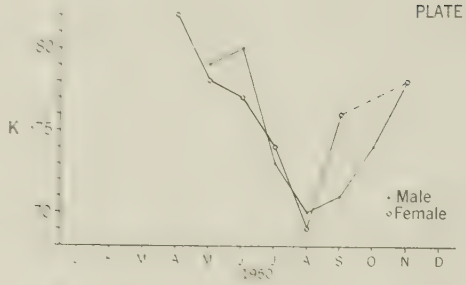


FIG 1

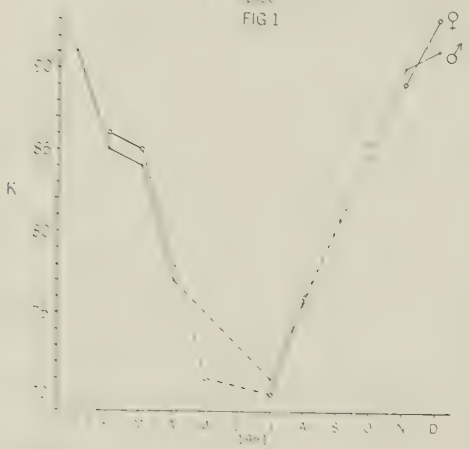


FIG 2

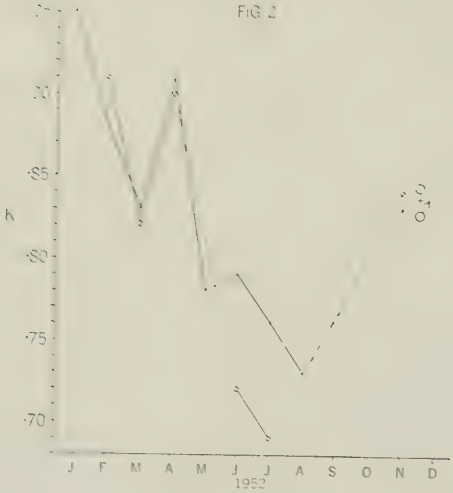


FIG. 3

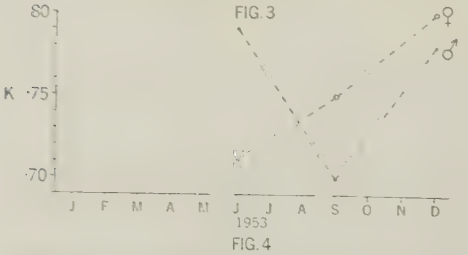
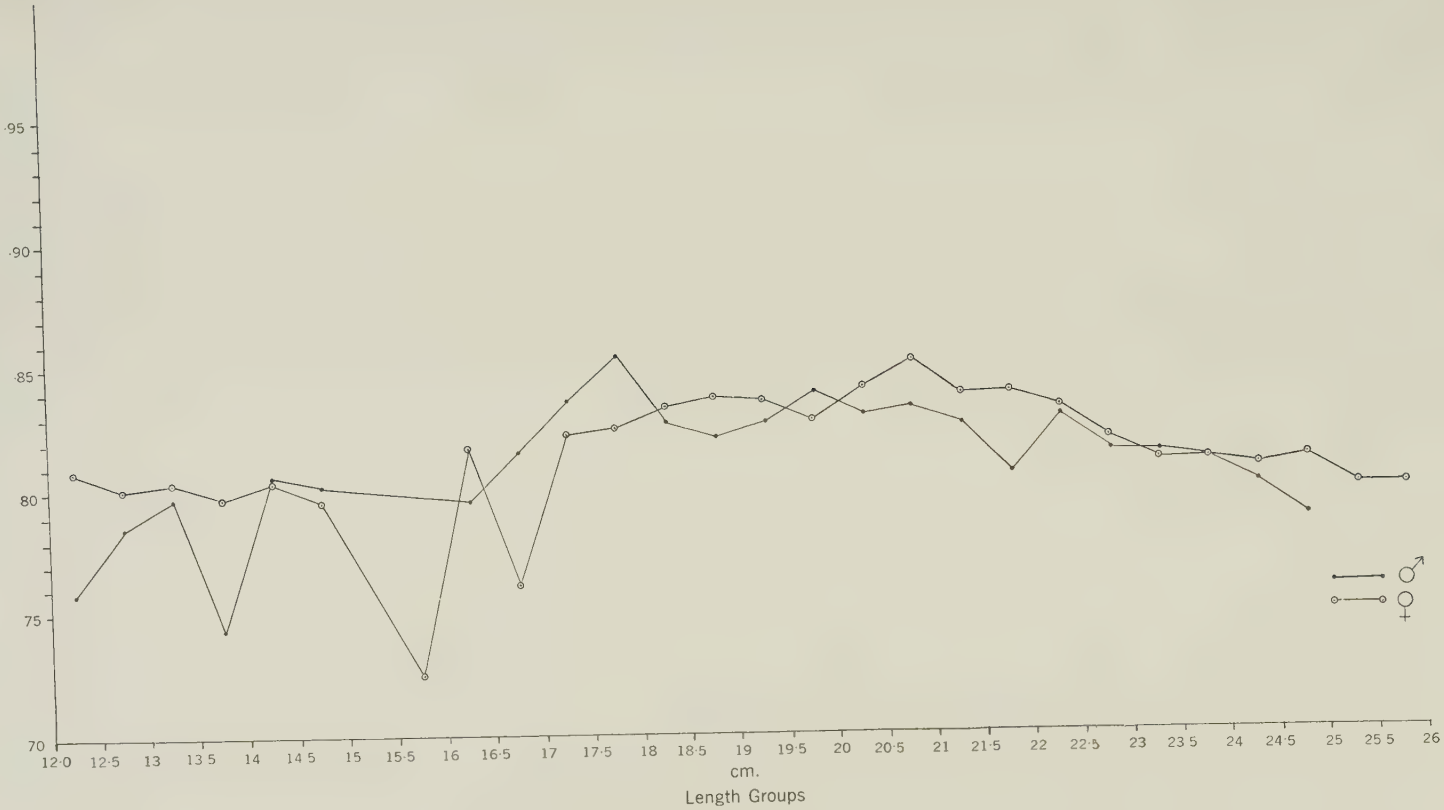


FIG. 4

CONDITION FACTOR FOR PILCHARDS OF LENGTH GROUP 18·0–18·4 CM.
Too few fish in 1954

Government Printer 1956



THE RELATIONSHIP BETWEEN CONDITION FACTOR AND LENGTH OF PILCHARDS, 1952.

Trigsurvey, 1956

Government Printer, 1956

Reprint from "Commerce & Industry", April, 1956

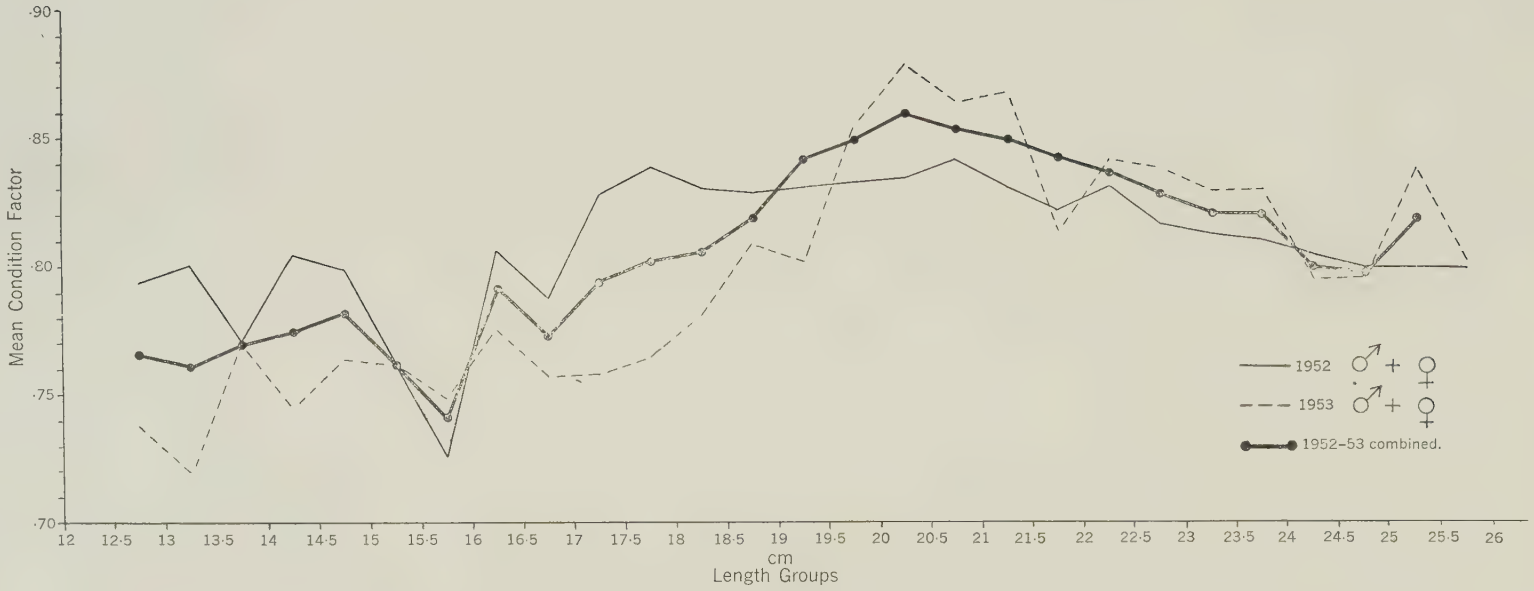
PLATE 42

THE RELATIONSHIP BETWEEN CONDITION FACTOR AND LENGTH OF PILCHARDS, 1953.

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 43



MEAN CONDITION FACTOR PER LENGTH GROUP FOR MALE AND FEMALE PILCHARDS (COMBINED) FOR 1952, 1953 AND 1952-53 COMBINED

Trigsurvey, 1956.

Government Printer, 1956.

Reprint from "Commerce & Industry", April, 1956

PLATE 44

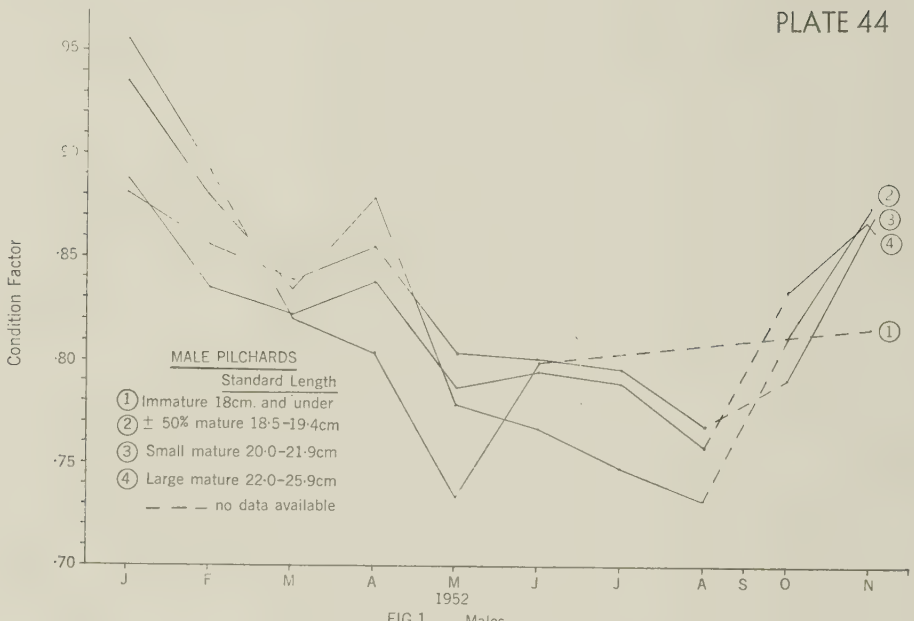


FIG. 1 Males

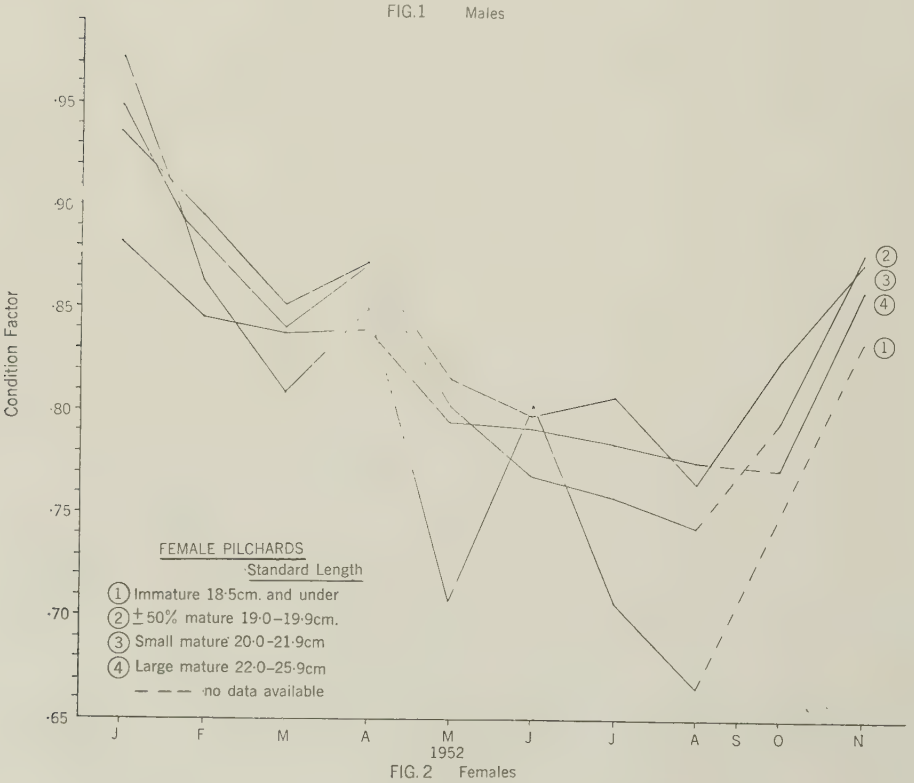


FIG. 2 Females

CONDITION FACTOR OF PILCHARDS IN RELATION TO STAGES OF MATURITY FOR 1952

Trigsurvey, 1956. Government Printer, 1956.

PLATE 45

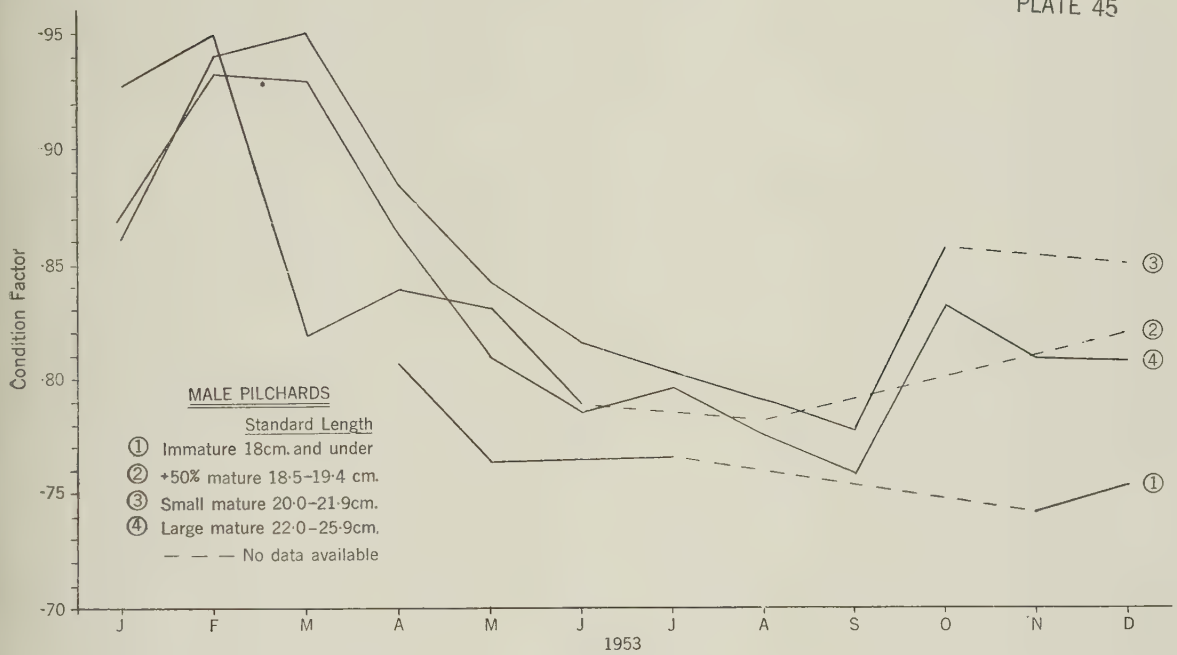


FIG. 1 Males

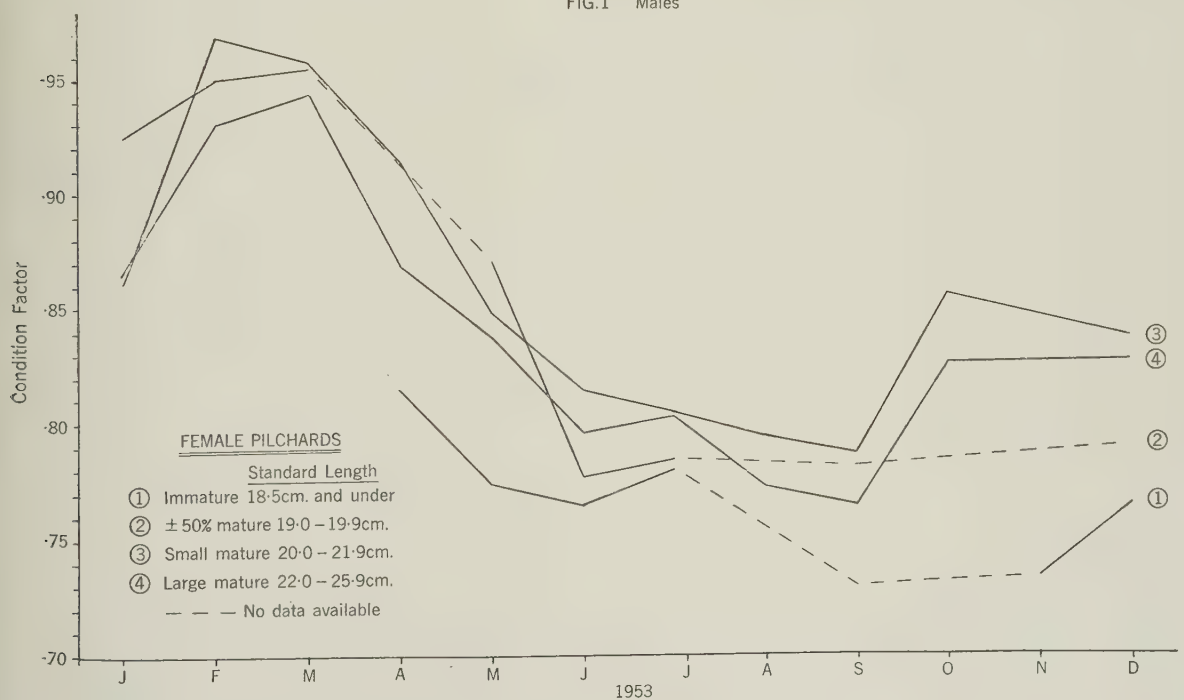


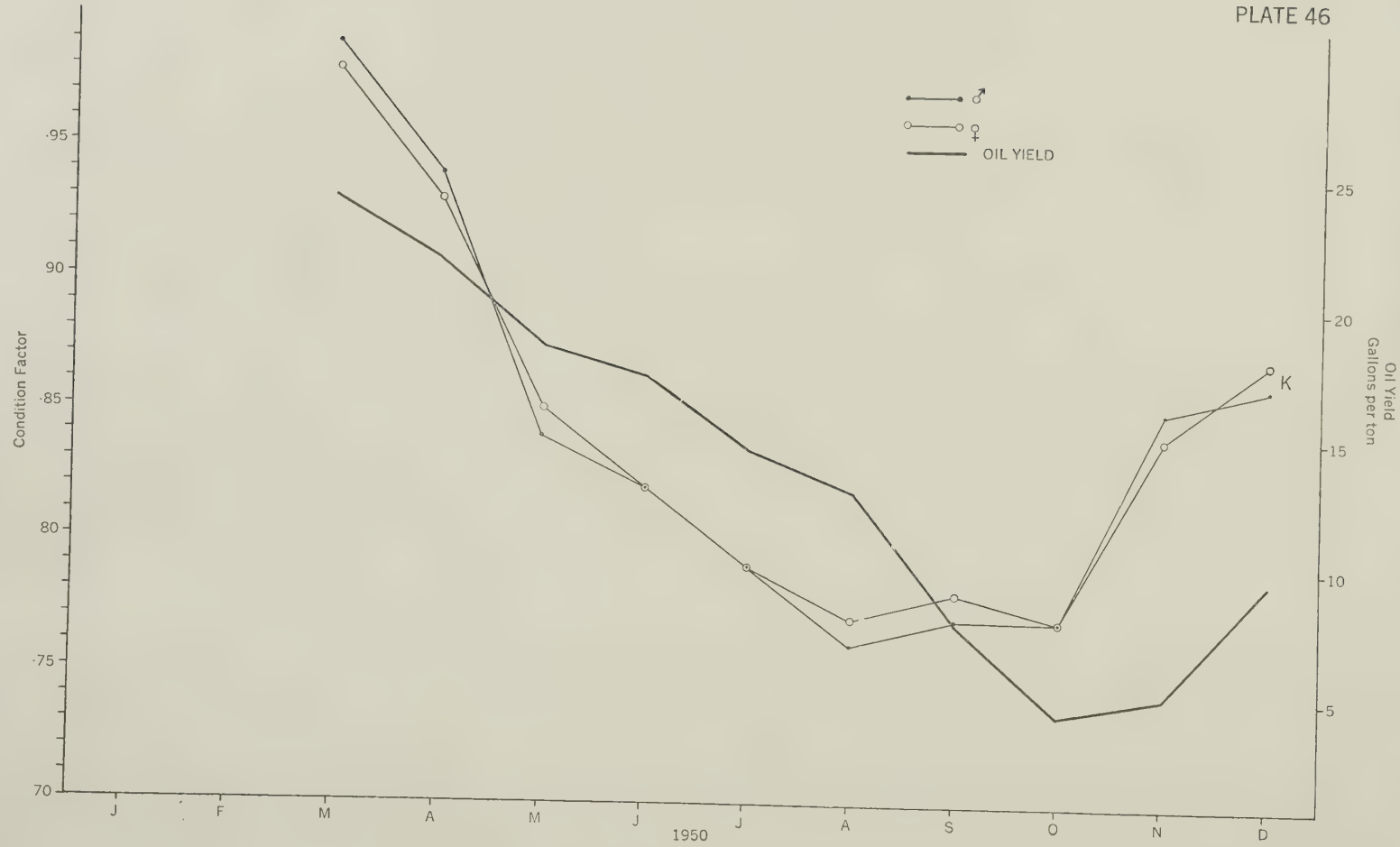
FIG. 2 Females

CONDITION FACTOR OF MALE AND FEMALE PILCHARDS IN RELATION TO STAGES OF MATURITY FOR 1953

Trigsurvey, 1956.

Government Printer, 1956.

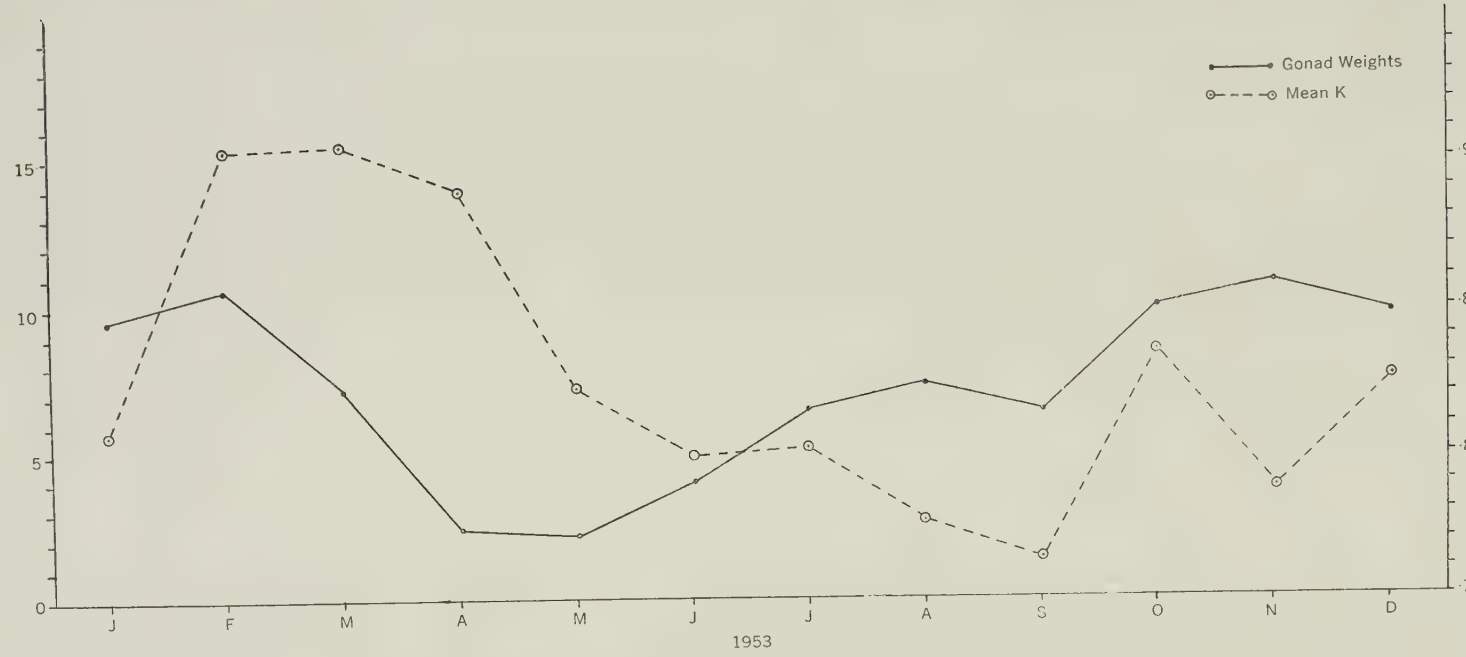
PLATE 46



CONDITION FACTOR FOR ALL FISH AND OIL YIELD FOR 1950

Trigsurvey, 1956

Government Printer, 1956.



GONAD WEIGHTS AND MEAN K FOR LENGTH GROUPS 21·5–24·5 CM.
(Data for ♂ and ♀ combined)

Trigsurvey, 1956.

Government Printer, 1956.

Reprint from "Commerce & Industry", April, 1956

PLATE 48

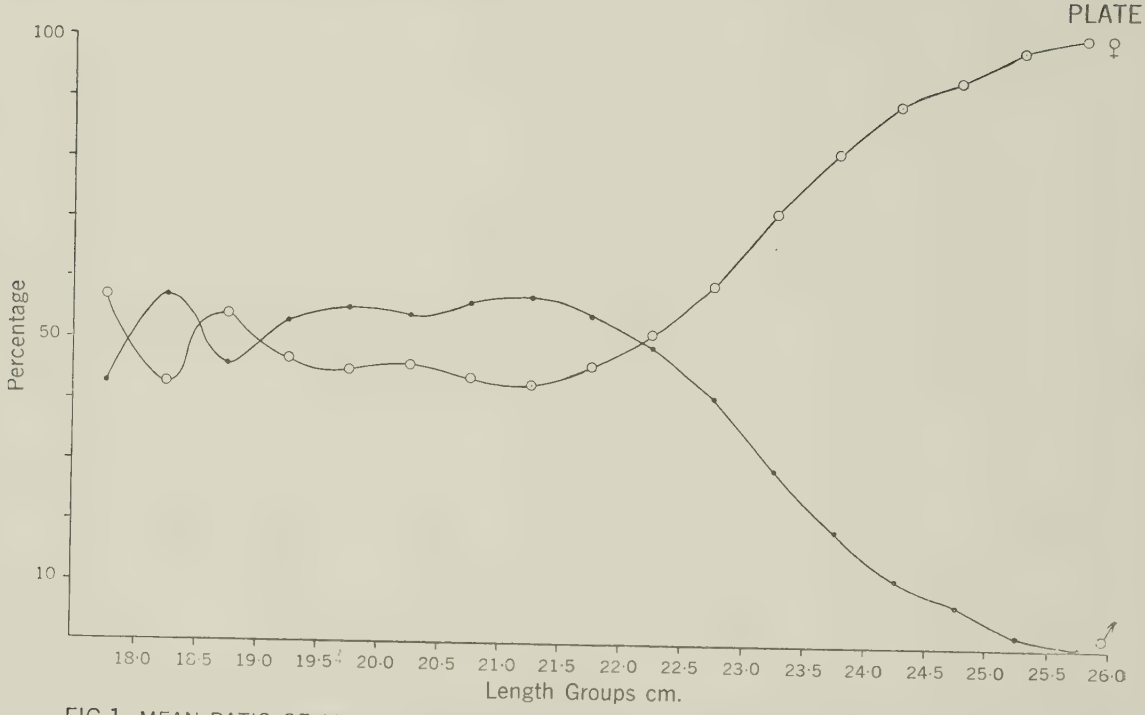


FIG.1 MEAN RATIO OF MALE TO FEMALE PILCHARDS IN RELATION TO LENGTH GROUP 1950-54

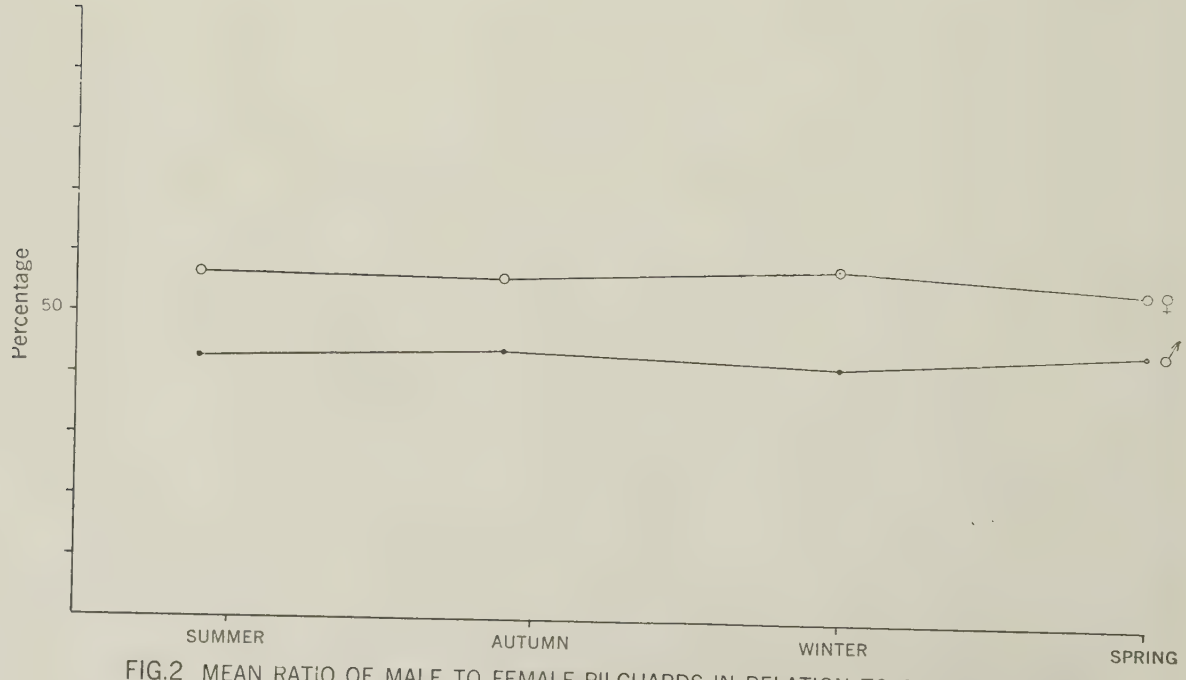


FIG.2 MEAN RATIO OF MALE TO FEMALE PILCHARDS IN RELATION TO SEASON 1950-54

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 49

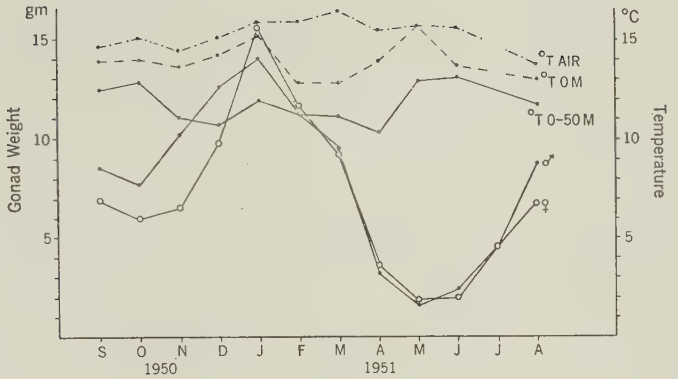


FIG.1

FIG.2

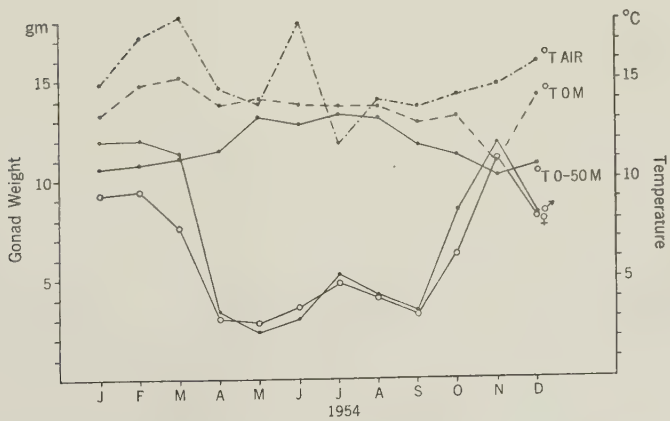
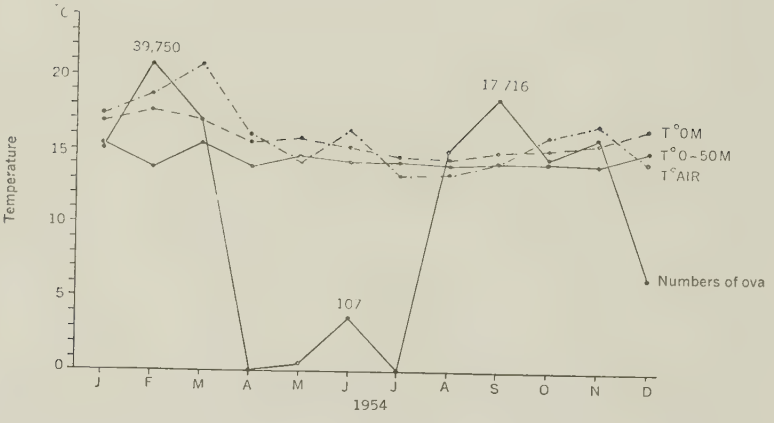


FIG. 3

GONAD WEIGHTS OF PILCHARDS IN LENGTH GROUPS 21·0-24·5 CM IN RELATION TO MEAN TEMPERATURES FOR 0-50 M, 0 M AND AIR IN ST. HELENA BAY

Trigsurvey, 1956. Government Printer, 1956.

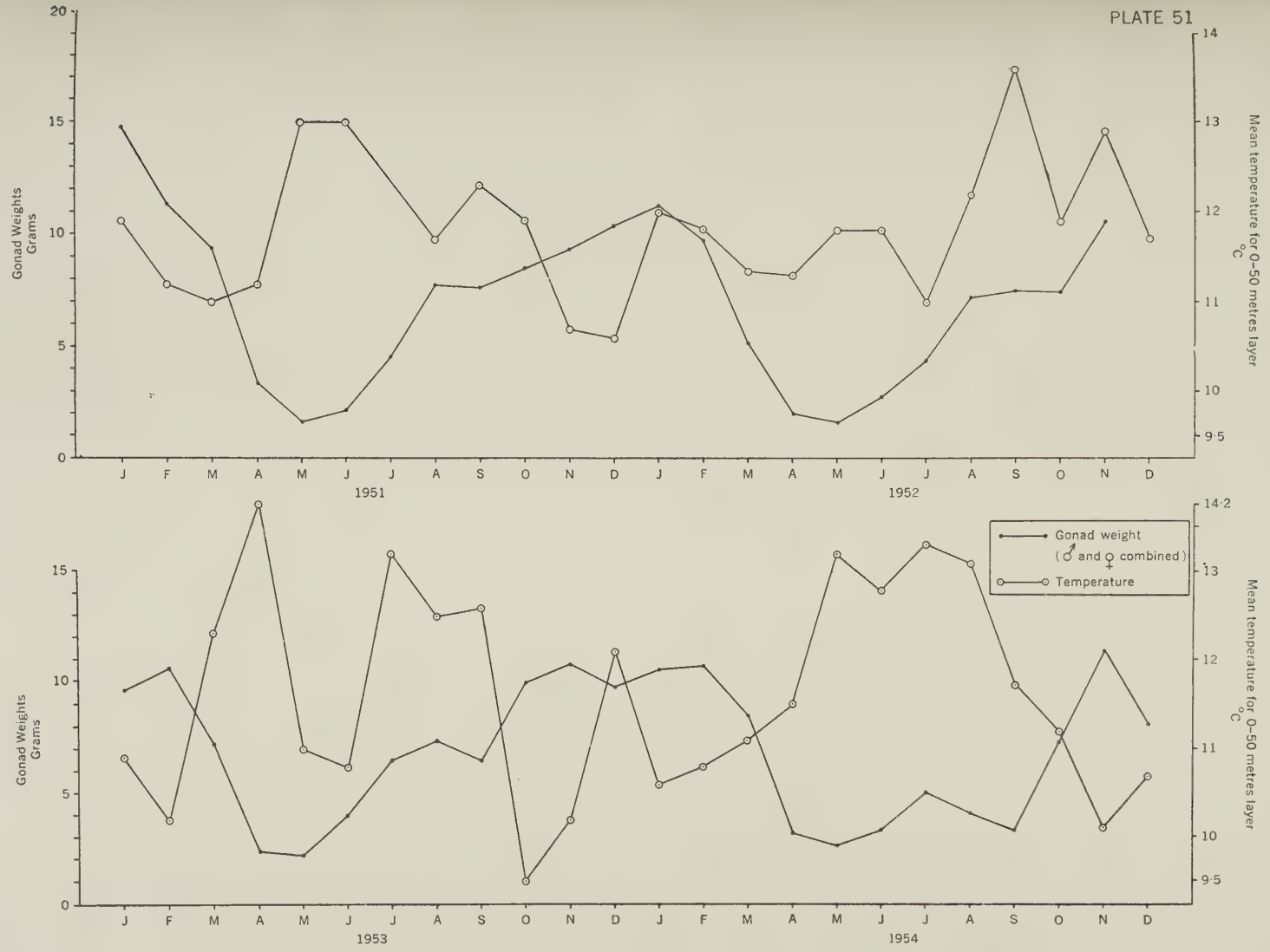
PLATE 50



NUMBERS OF OVA AT ROUTINE OFFSHORE STATIONS AND TEMPERATURES AT 0M, 0–50M AND AIR FOR STATIONS AT WHICH OVA WERE COLLECTED

Trigsurvey, 1956.

Government Printer, 1956.


Gonad Weights Grams
Mean temperature for 0-50 metres layer °C
Gonad weight (♂ and ♀ combined)
Temperature
J F M A M J J A S O N D J F M A M J J A S O N D
1951
1952
1953
1954

GONAD WEIGHT IN RELATION TO 0-50M MEAN TEMPERATURES 1951-54

Trigsurvey, 1956.

Government Printer, 1956.

Reprint from "Commerce & Industry", April, 1956

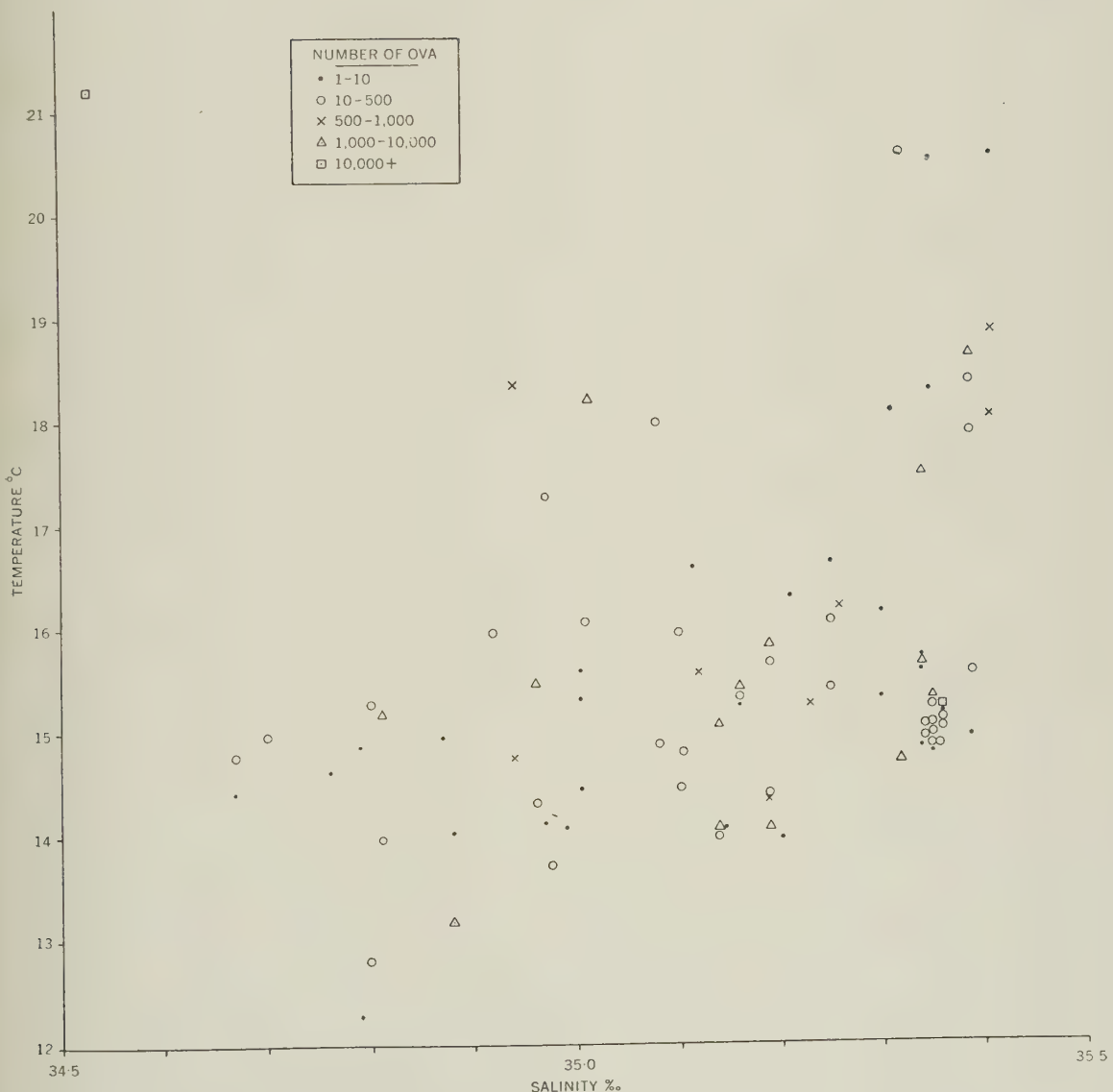
PLATE 52

MEAN GONAD WEIGHT IN RELATION TO MEAN TEMPERATURE 0-50 M LAYER FOR FOUR YEAR PERIOD 1951-54

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 53



THE RELATIONSHIP BETWEEN OVA DISTRIBUTION, TEMPERATURE AND SALINITY AT 0M.

Trigsurvey, 1956.

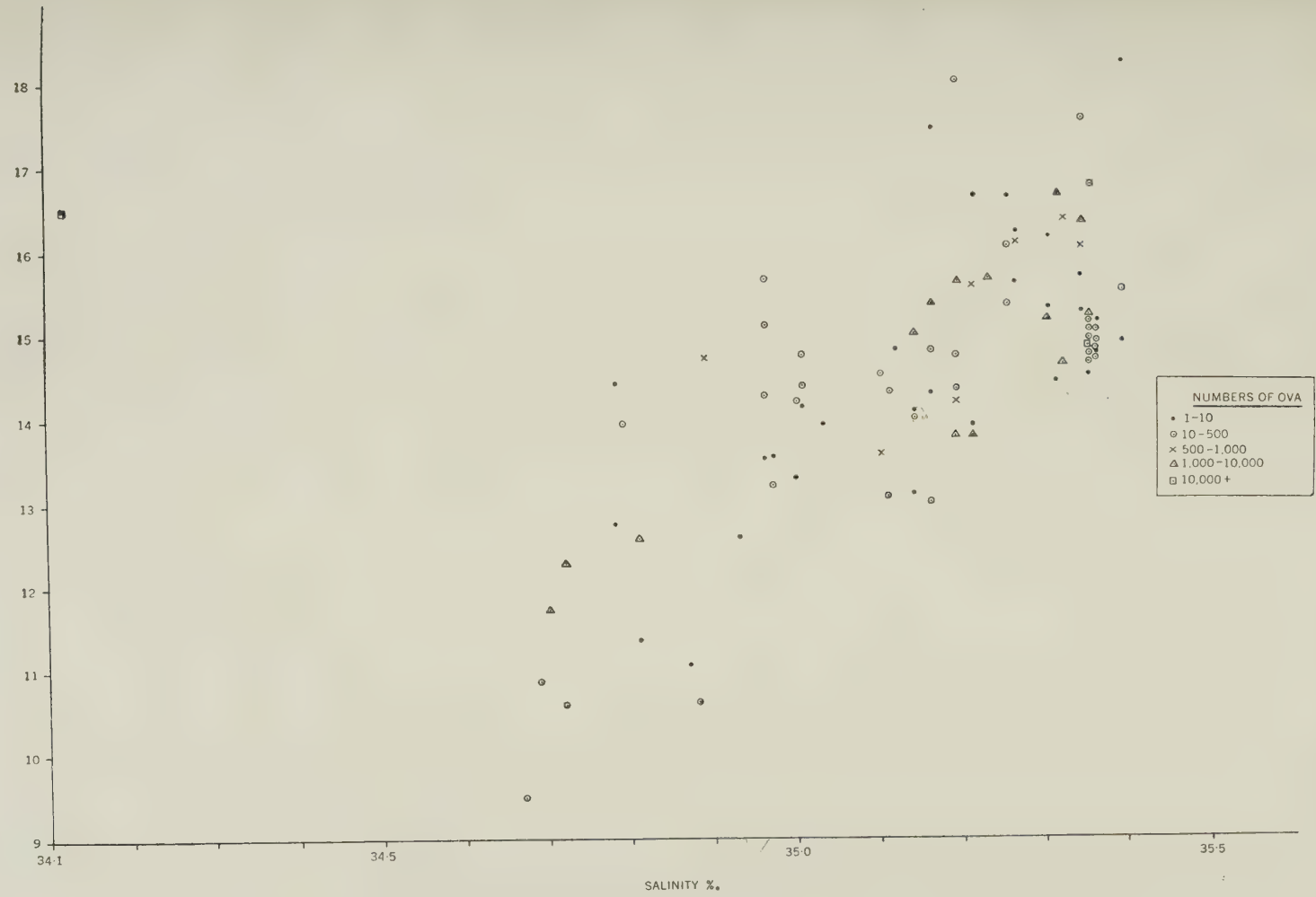
Government Printer, 1956.

PLATE 54

THE RELATIONSHIP BETWEEN OVA DISTRIBUTION, TEMPERATURE AND SALINITY AT 10M.

Trigsurvey, 1956.

Government Printer, 1956.



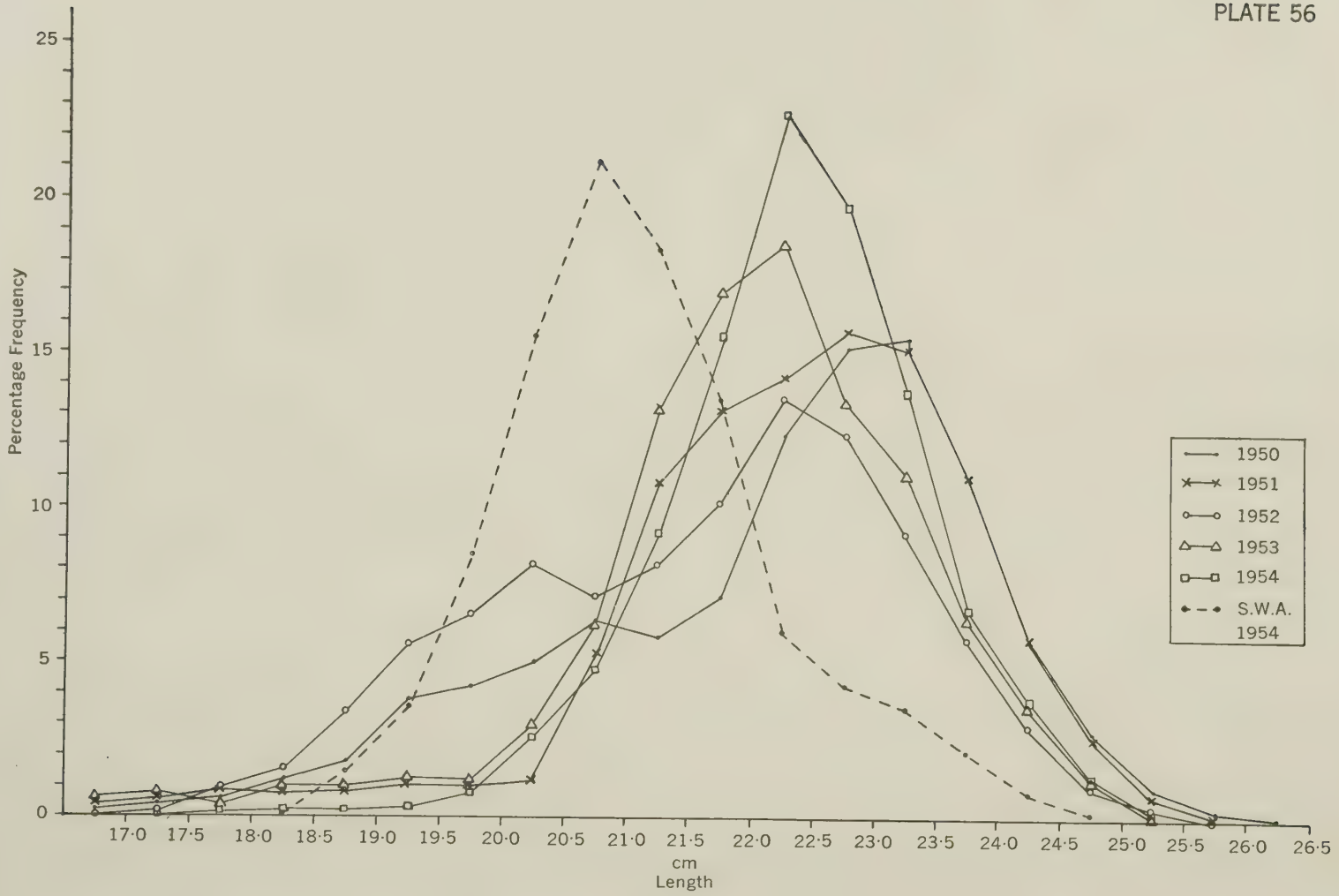
THE RELATIONSHIP BETWEEN OVA DISTRIBUTION, TEMPERATURE AND SALINITY AT 20M.

Reprint from "Commerce & Industry", April, 1956

Trigsurvey, 1956.

Government Printer, 1956.

Reprint from "Commerce & Industry", April, 1956

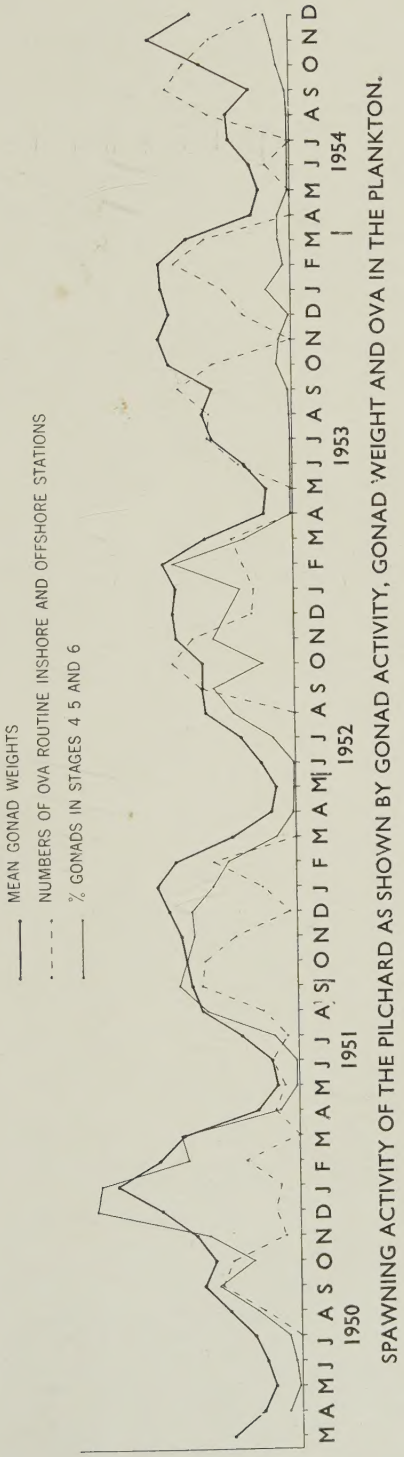


PERCENTAGE FREQUENCY PER LENGTH GROUP OF PILCHARDS (♂ AND ♀) FROM COMMERCIAL CATCHES 1950–54 AND S.W. AFRICA 1954

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 57


MEAN GONAD WEIGHTS
NUMBERS OF OVA ROUTINE INSHORE AND OFFSHORE STATIONS
% GONADS IN STAGES 4 5 AND 6
M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1950
1951
1952
1953
1954

SPAWNING ACTIVITY OF THE PILCHARD AS SHOWN BY GONAD ACTIVITY, GONAD WEIGHT AND OVA IN THE PLANKTON.

Trigsurvey, 1956

Government Printer, 1956